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A BRITISH INSTITUTE OF MANAGEMENT

THE committee appointed last November by the President of the Board of Trade under the chairmanship of Sir Clive Baillieu, president of the Federation of British Industries, to formulate detailed proposals for setting up a central institution for all questions connected with management, was both strong and thoroughly representative of industry and of the Government service, and its report* shows that the committee has taken the wide views that might be expected. The President of the Board of Trade has already announced his full agreement with the general recommendations of the Committee, and the report is assured of widespread interest and careful study by the increasing number of those who realize the critical importance of efficient management at the present time.

In view of the inquiry already undertaken by Sir Cecil Weir's committee, which had shown the need for a central institute of management and the general readiness of existing organisations to collaborate in its formation, the Baillieu Committee did not take further evidence from the existing management associations, institutes, etc.; but was agreed that the need for a central institute is urgent. Furthermore, in accordance with that body of opinion which holds that any developments in the direction of a 'staff college' should not be limited to the Civil Service but secure the mixing of Civil servants with administrators from public corporations, local government service and industry, the Committee recommends that the proposed institute should be called "The British Institute of Management", and should ultimately embrace all questions of management in the widest sense in industry and commerce, in national and local government, public enterprise, agriculture and institutional management. By taking the lead in promoting research into management problems, co-operating in the development of training and educational schemes, and undertaking widespread propaganda on good management practice, the Institute should aim at raising the standards of management throughout Britain and maintaining them at a high level, helping to create in industry and commerce a continuous supply of good managers and stimulating a lively appreciation of the importance of effective management at all levels by all concerned.

It will be noted that, in urging that the Institute must both assist in promoting the means of training and education whereby those engaged in management may equip themselves to discharge their functions more effectively and also take a lead in promoting inquiry and research into management problems, the Committee is seeking to implement the recommendations of an important section of the report of the Percy Committee on Higher Technological Education. That report recommended the selection of at least one

* A Central Institute of Management. The Report of a Committee appointed by the President of the Board of Trade in November 1945 to formulate detailed proposals for setting up a Central Institute for all questions connected with Management. (H.M. Stationery Office, 1946.) 3*d*. net.

institution as a centre for postgraduate study of industrial administration, and that management studies should form a part of the courses, not only of universities and colleges of technology but also of all technical colleges teaching for the national certificates and diplomas, as well as of short or refresher courses organised jointly by teaching institutions and industry. The proposed Institute would set its own standards for admission to its several grades of membership, but would also co-operate in the development of such courses of instruction for students at all levels to enable them to attain these standards, and encourage firms to give members of their staffs every opportunity to take advantage of courses of further training. Similarly, besides research undertaken by the Institute itself, it could make a major contribution by initiating, encouraging and giving financial aid to enable research to be undertaken by appropriate specialist and other bodies.

The Institute should have its own research, training and propaganda divisions, an early start with the research division being specially important, and should be organised as a strong central body, ably directed and adequately staffed, and working in close co-operation with those existing management bodies which are effective in their own specialist fields, assisting them in every possible way to become more effective, co-ordinating and harmonizing their activities and bringing them together by affiliation. It should aim at establishing itself as a professional body having defined grades of membership of individuals, the highest standards being set for admission to the top grades. The status of a professional institute must be earned by performance, and the Committee believes that the proposed Institute should be left with as much freedom as possible to work out its organisation for itself as it becomes established, and as its relationship with other bodies develops. Its success in thus establishing itself will depend upon its ability to determine criteria by which individual capacity in management can be assessed.

Here, no doubt, the new Institute may be able to draw on the experience of such bodies as the Institute of Industrial Administration, but the Committee recommends for a start two broad categories of individual membership: first, those who produce evidence which satisfies the council of the Institute that their calibre and practical experience make them suitable persons for election as full members, with the privileges of playing a full part in its management and activities and using letters to indicate their membership; and secondly, all others interested in the objects of the Institute and desiring to be associated with it, receiving its literature and attending its meetings as appropriate. In addition to this, however, it is suggested provision should be made for trade associations, trade unions and other bodies which do not claim management to be their primary concern to interest themselves in the work of the Institute. By thus helping to create throughout the country a continuous supply of good managers, by its efforts to raise the standards of management practice and by serving as a bureau of information on management problems, maintaining a library of management literature and organising conferences on management, the Institute will serve industry and commerce well. In return, the Committee considers it will deserve the full support of individual firms, and every encouragement should be given to them to become subscribing members with representation on its governing body.

The report stresses that the ultimate aim of the Institute should be to establish itself as a professional body with defined grades of membership, with appropriate criteria for each grade, including practical experience as managers. There can be little doubt that in this way it will make one of its most important contributions to the raising of standards of management. Valuable as may be the stimulus which it could give to research on management problems, the establishment of recognized professional qualifications should greatly assist the increased mobility and interchange which are so desirable between industry and commerce, and the administrative grades in the public corporation and the national or local government service. The possibility of expansion and contraction in the Civil Service to meet the extension of social services, nationalization of industries and also population changes, and to keep a balance between productive and non-productive occupations, in the material sense, to which a recent motion by Lord Balfour in the House of Lords directed attention, emphasizes the importance of this; just as the general shortage of man-power and the trend of population changes stress the urgent need for management in government service as well as in industry to make the most efficient use possible of available man-power.

It is one of the advantages of the present situation, from which the British Institute of Management may profit in due course, that the needs of the war years have drawn into the government service a considerable number of qualified administrators and students of administration from industry and the universities. Those thus qualified to look at the working of the Civil Service, for example, both from within and from without, may make important contributions to the current special discussion on Civil Service administration, as well as to more general questions of management. An article by "A Temporary Civil Servant" in the *Political Quarterly* (**15**, 93; 1944) has already shown how valuable such a contribution can be, and a further example is to be found in Prof. R. S. T. Chorley's contribution to the final issue of *Agenda*.

Besides the functions already indicated, the Baillieu Report suggests that the proposed Institute should serve as a body to which educational authorities, technical colleges, universities and other educational agencies can look for advice and assistance in the development of courses of instruction for students at all levels. It should disseminate information about management practice and technique and current developments therein by arranging discussions on management questions, publishing a journal of proceedings and the results of specific studies, and by any other appropriate means. It should also maintain contact with management bodies and management practice in other countries, and in particular should

become the recognized body for organising British participation in international management congresses, although the British Management Council should be left to organise British participation in the International Congress to be held in Stockholm in September 1946.

In regard to the constitution of the Institute, the report recommends that its council should reflect appropriately its several constituent elements, and while it is recommended that the Government should nominate the first chairman and the first council, the Institute should thereafter be left as an independent body responsible for its own affairs. Financial assistance will be needed from the Government during its first five years, and for this purpose the Government has already promised a grant not to exceed £150,000. After this period, the Institute should become self-supporting. If it is unable to reach this position in the time, continued government aid on a moderate scale would be warranted in the national interest, provided that it is succeeding in its aims. While the headquarters should be in London, the Institute should be planned from the beginning to operate on a country-wide basis. When the headquarters organisation has been firmly established, the Institute should develop regional centres, the first of which should be established in Scotland not later than the second year.

It is not easy to measure at this stage the importance of the contribution which the proposed Institute might offer towards raising the standard of management in industry, business and the public services. The whole trend of the report is against any attempt to discriminate between the different fields of administration in this respect, and as the Institute proceeds to build up a real professional body of administrators, it may make a most valuable contribution to the fuller understanding between Government departments and industry which is of such growing importance. No matter what distance Britain proceeds along the path of nationalization of its industries and public services, a much clearer understanding between those responsible for the management of private enterprise and of Government departments is essential in order that social security policies may be administered effectively and the task of reconstruction in the social and the industrial fields carried out efficiently. Already the interchange between the service of the State and the universities and industrial or commercial life is facilitating that understanding, and the existence of a body of professional men of recognized qualifications should further facilitate the mobility and interchange on which repeated stress has been laid in recent years.

Meanwhile, it is clear that the publication of this report and the Government decision to establish such an Institute of Management will stimulate the re-examination of the findings of such reports as that of the Assheton Committee on the training of Civil servants and the White Paper on Recruitment to Established Posts in the Civil Service during the Reconstruction Period, if only to see that no interim measures are inconsistent with the long-term trends which the new Institute makes possible.

ORIGINS OF BELIEFS IN IMMORTALITY

Death and Rebirth

A Study in Comparative Religion. By Lord Raglan. Pp. vi+106. (London: Watts and Co., Ltd., 1945.) 5*s*. net.

LORD RAGLAN dedicates this book to the memory of A. M. Hocart, the most original anthropologist of this century, whose "Kingship" (Oxford, 1927) and "Kings and Councillors" (Cairo, 1936) are still less well known than they should be. "Kingship" is an analysis of the complex pattern of kingship in its prehistoric heyday, which can perhaps be correlated with Gordon Childe's 'urban revolution' (in "Man Makes Himself"), and in its modern survivals. Hocart points to a single origin of the institution and of the archaic culture of which kingship was the unifying symbol, in the fourth or third millennium B.C. in the Near East, and to its diffusion from there. Lord Raglan's "Hero" (1936) was an extension of Hocart's work and argued that myths of heroes all over the world exhibit the same pattern, a threefold repetition of the ritual life of the divine king covering his birth, his coronation and marriage, and his death. In "How Came Civilization" (1939) Lord Raglan developed some of the ideas which Hocart had thrown off and left uncompleted in his "Progress of Man" (1933), ably supporting the diffusionist hypothesis and giving particular examples of artefacts, like bows or the potter's wheel, or of techniques, like the domestication of animals or mummification. He ended with a striking chapter on the dominance of ritual in the 'archaic civilization', which is the foundation of ours to an extent which few of us begin to suspect. "Death and Rebirth" continues the argument in the sphere of beliefs about immortality and life after death.

The theory of the independent origin of such beliefs is shown to be almost as absurd as the notion that Christianity, for example, could have arisen in several places or periods. Beliefs are transmitted like artefacts, indeed usually with them, except that beliefs are less subject to limitation. Beliefs are not the result of abstract speculation, but of tradition, and tradition is transmitted by ritual. Even in their origin they are not speculative but practical. Lord Raglan traces three stages of belief: (1) that something survives death; (2) that this goes to a world of the dead; (3) that death for the ritually qualified is a promotion to a higher and happier sphere. He gives some examples of the particular forms and distributions of transmigration (of the soul into a non-human body) and reincarnation (in a human body). Such beliefs are not the natural and inevitable result of the 'savage philosopher's' speculation, but are distinct and often contradictory, where a later stage, not involved in the earlier, is overlaid on it by a new wave of culture. They are not 'primitive' or 'savage', but the product of the highest civilizations of their day, and owe their diffusion to their being part of a whole superior complex of culture. Such self-contradictory ideas as that of the multiple soul (part going to heaven, part to the underworld, part remaining in the grave) are attempts to combine the dogmas of successive waves of culture. The latest belief, in death as promotion and rebirth to a higher sphere, is the central idea of divine kingship. Initiation, coronation and marriage are all ritual deaths. A belief in a happy immortality is nowhere found

without such a ritual. This ritual at first belongs to kings only and is only gradually democratized.

Lord Raglan is not a professional anthropologist, but he is a very able and widely read critic who often sees more of the game than the players. He insists on interpreting prehistory in the light of what we know of history, and on attacking the problem as a whole. He is a rationalist, but is especially impatient of rationalists who unhistorically think it easy to relive the past and to understand the original motives for practices which are continued for very different ones and very superficially rationalized. He delights in making havoc of those who take beliefs without the rituals necessary to them and out of their whole cultural context. He argues with pungency and apt examples, and it is difficult to disagree with his critical conclusions. But after this enjoyable dissipation of fallacies, we are left with a feeling of disappointment at his reductive method, like that of psycho-analysis, by which vast consequences are traced to an incident of childhood. In his "Jocasta's Crime" (1933) we were pushed back to an intermarrying group, squatting on both banks of the Nile, for the origin of the vast ramifications of exogamy and the dual organisation; so here everything turns on the origin of the ritual system of the divine king, and this, in Lord Raglan's view, seems to be nothing but a historical accident. It seems to be the nemesis of diffusionism that, in insisting on the uniqueness of discovery, it is tempted to deny any creative act, any emergence of anything new, or at least to depreciate it as a mere accident. He is far from the Aristotelian belief that "Nature makes nothing in vain". To him the great ritual of the divine king and the myth of the hero is a mere phantasmagoria and proof of human credulity and of enslavement to tradition, even if the first formation of the system was accompanied by the amazing inventiveness of the 'first industrial revolution'. He is convinced that the purpose of ritual is earthly prosperity only. Ritual gives rise to belief and never vice versa, and it begins in an unguessable coincidence (p. 29). The source of trouble is his view of symbolism. "The wildest imaginings of poets and mystics are merely combinations of ideas . . . from ordinary mundane sources"; "it is impossible for any human being to imagine anything which he has not seen or heard of"; "there must be a real thing before there can be a symbol"; "a symbolic killing can only be a substitute for, or an imitation of, a real killing"; "symbolism proceeds from the seen to the unseen". Invention is doubtless rare: this makes it impossible. Somebody must first have imagined the creation of the world from the body of a dead giant and then somehow imposed the ritual expression of it on others, making them kill a man for the purpose.

Lord Raglan perhaps underrates the importance of dreams, though right in rejecting most theories based on them. Are the visions of Constantine the Great and of Mahomet not the unique and inexplicable origins of vast historical movements? Jung's study of dreams has thrown a new light on symbolism. Alchemical and astrological symbolizations of psychic processes, for example, occur in the dreams of modern men. We can grasp, or perhaps even experience, a psychic process only in terms of visible reality. Yet dreams produce spatial forms not found in sensible space, like crosses, circles within squares, or stepped pyramids. Sacrifice may likewise be a form in which the psyche expresses itself in terms of visible reality, but not derived from it, any more than an aero engine is. Material inventions were made once and once only: why should the same not apply to psychological discoveries, if the death and rebirth of the king symbolize an interior psychic process of renewal? It would then be the dramatization of a process, necessary for everyone, of psychic integration; the discovery of the self. The archaic civilization developed this great psychiatric system of symbolic psychology, but in 'projection', confused with outward actions and events, because largely expressed in terms of them. Barbarian invaders proved to peaceful kingdoms that battles are not won by ritual alone. The two spheres, of ritual and physical science, have to be distinguished before they can be rightly related to each other. Alchemy shows how closely they are intertwined.

In his first chapter Lord Raglan makes easy and amusing game of the arguments for immortality advanced by some modern Christians, the conservation of values, dormant desires, immediate intuitions, conformity to certain human needs, value for temporal survival. He quotes Hume that "the Gospel alone has brought immortality to light". Clearly the belief existed long before the Gospel, but it is not obvious that this refutes Christianity. Lord Raglan avoided the question in the "Hero" when he declined to consider Jesus as exemplifying the hero pattern. In his present book the only two writers on comparative religion whom he commends in addition to Hocart are Profs. James and Hooke.

Lord Raglan does good service in pointing out the unhistorical abstractness of what passes for philosophical examination of belief, and in emphasizing the great importance of the ideas of the archaic civilization, in which war, for example, began as the institution it is, and not in an unproved 'primitive savagery' or other such abstraction. It is to be hoped that he will follow up this book with a study of the origin and diffusion of war, and of the divine king in modern politics and political theory.

COLIN HARDIE.

SUNFLOWER CULTIVATION

Sunflower for Food, Fodder and Fertility

Its Economic Value, World Expansion and Cultivation with Particular Reference to Great Britain. By E. F. Hurt. Pp. 155 + 20 plates. (London: Faber and Faber, Ltd., 1946.) 10s. 6d. net.

EARLY in the war-period, Britain's urgent need for edible oils directed attention to the sunflower as a potential source of supply. In the U.S.S.R., Rumania and the Argentine the sunflower had long been grown extensively for this purpose and, more recently, the crop has made considerable headway in the U.S.A., Canada, Uruguay, Hungary, Rhodesia and other lands. The sunflower is a rapidly growing annual which is very catholic in its requirements and each plant produces an enormous number of seeds which contain 32–45 per cent of oil. Sunflower oil is a semi-drying oil consisting largely of the glycerides of oleic, linolic and palmitic acids with a small amount of linolenic acid. For human consumption it is equal to the best olive oil in its medicinal and feeding value, in its lack of taste and colour and in its keeping qualities, and it has the advantage over olive oil in that it remains liquid at a lower temperature. For margarine it is probably in the top rank, it is an excellent salad oil and in many countries it is used in

place of olive oil or lard for cooking. The seeds are an excellent poultry food, and, after expression of the oil and removal of the indigestible husks, the crushed residues form a valuable feeding cake for stock.

In Britain the sunflower is a familiar sight in every cottage garden, but we had no experience of it as a crop plant. Accordingly, in 1940, with the support of the Ministry of Agriculture and the Agricultural Research Council, Prof. G. E. Blackman started experiments to discover whether sunflowers could be grown successfully in Britain as a new oil-seed crop. The work followed many different lines—varieties suitable to British soils and climatic conditions, problems of soil preparation, sowing, cultivation, harvesting, seed treatment and disposal of residues, pest and disease control—and Prof. Blackman's two published reports (*Agriculture*, 1944, 1946) together with the data given in this book hold out considerable promise that the crop can be grown and utilized successfully. With the present varieties, however, the crop is suitable only for the earlier soils in the drier parts of England, that is, the region east of a line running from Hampshire to the Wash. Further, it would seem that the industry should be planned on an area basis, as with flax and sugar beet, each area centring about a station for seed-drying and the utilization of the by-products.

Mr. Hurt's well-illustrated book deals with the husbandry of the sunflower crop rather than with the botany of the plant. He gives a clear picture of the development and the present situation of commercial sunflower growing in Britain with interesting comparisons of the industry in other lands, of the problems which have been solved and of the difficulties that confront us. Unfortunately, as Mr. Hurt states, this promising industry has been "the plaything of various interests—the agricultural seed trade, the bird seed trade, some earnest growers, and a number of speculators". It will be a great pity if these and the many other interests that tend to bedevil agriculture interfere too much with the natural evolution of the industry, the future of which, in Britain, in the long run, must depend on world prices for farm products and the relative yields and costs of production.

W. B. Brierley.

AMERICAN TECHNIQUES IN PHYSICAL CHEMISTRY

Physical Methods of Organic Chemistry
Edited by Arnold Weissberger. Vol. 1. Pp. vii+736. (New York: Interscience Publishers, Inc., 1945.) 8.50 dollars.

VOLUME 1 on "Physical Methods of Organic Chemistry" which Interscience Publishers of New York have issued in a new series on "Techniques of Organic Chemistry" is one of the many recent American scientific books which will, on grounds of cost, probably be consulted in reference libraries by most English readers and not purchased for personal use. It has to a surprising extent copied in style both the merits and the defects of German technical handbooks. The printing and illustrating are excellent, and references have been included with Teutonic frequency; but most contributors have treated their subjects very narrowly, by referring almost exclusively to recent American work, and describing specialized instruments of particular American firms or university laboratories.

The book is intended to explain modern physico-chemical techniques to the organic chemist; it does in fact deal throughout with theoretical and practical requirements for the attainment of high accuracy in the determination of physical data. Hence the title is a definite misnomer, since apart from the inclusion of a useful account (by E. E. Jelley) of microscopic methods, the practical organic chemist will find in it little to widen his everyday range of laboratory techniques. Either the term 'organic chemistry' has a good sales value in the United States, or else the American chemist must begin to specialize so soon that he can only be brought by subterfuge to read basic physics.

The separate chapters vary widely in their scope and treatment. Those on determination of melting point (by E. L. Skau and H. Wakeham), condensation temperature (by W. Swietoslawski), density (by N. Bauer), solubility (by R. D. and M. J. Vold) and diffusivity (by A. L. Geddes) describe few particularly novel methods, but go into theoretical detail. Two chapters (100 pages) by W. D. Harkins on surface tension and properties of mono-layers deal, extremely thoroughly, with particularly accurate methods developed in the author's own laboratory, but give very little space to indicating the value of such data to the organic or bio-chemist.

A long (124-page) chapter on calorimetry by J. M. Sturtevant has obviously been written by a man with the interests of a physicist. Thus while the physical sources of error in bomb calorimetry are discussed in detail, the possibility of formation of oxides of nitrogen during an organic combustion is mentioned in but a single sentence, and the serious difficulties encountered in dealing with halogen or sulphur compounds are ignored completely.

Osmotic pressure is dealt with too briefly, but well, in 24 pages by R. H. Wagner, and a 14-page account of viscosity by H. Mark is quite inadequate for this important subject. The author is only able to refer sketchily to the Ostwald viscometer and to a few of the standard formulæ for estimating the molecular weights of high polymers. Refractometry (by N. Bauer and K. Fajans) gets 80 pages, however, and deals with the standard Pulfrich and Abbe instruments in a way that is most helpful to the organic chemist.

Two chapters on determination of crystal form (by M. A. Peacock) and crystallochemical analysis (by J. D. H. Donnay) and one on X-ray diffraction (by I. Fankuchen) cover the theoretical principles of these subjects in a total of 90 pages, but none of them details laboratory methods or attempts to show, by practical examples, the especial values, and limitations, of these techniques. In contrast, L. O. Brockway's 30-page account of electron diffraction concentrates very successfully on putting this new subject in its proper perspective.

Whereas "Physical Methods of Organic Chemistry" is a sound scholarly book taken part by part, it bears evident marks of having been assembled hurriedly from the manuscripts of enthusiastic specialists who have not considered the requirements of the majority of their readers. More careful editing, to attain co-ordination in scope and outlook, will be needed if future volumes of this series are to find their proper place among useful works of reference. They will, however, be awaited in Britain with interest, for there is a real need for books in English which will replace such obsolescent German "Handbuchs" as Houben-Weyl's "Arbeitsmethoden". W. A. Waters.

Advanced Mathematics for Technical Students

By A. Geary, H. V. Lowry and Dr. H. A. Hayden. Part 1. Pp. viii+419. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1945.) 12*s.* 6*d.*

THE mathematical historian of the future will undoubtedly mark the present epoch as one characterized by the rapid development of the practical aspect of mathematics, in contrast to the earlier period of purely abstract research. The Second World War has contributed very materially to this important phase, and the pure mathematician of the future will have to broaden his outlook in order to appreciate fully this essential side of his subject.

The volume under review is a significant pointer to the modern trend. It not only emphasizes, in a skilful manner, the applications of mathematics to the present-day problems confronting technical students, but also, incidentally, sweeps away the artificial barriers traditionally erected to segregate the many departments of the subject. Here, in a single volume of more than four hundred pages, is contained an admirable treatment of the elements of the practical theory in outline of functions, series, calculus, co-ordinate geometry, rectification and quadrature, approximations to the roots of equations, complex numbers and functions, simple differential equations, and the elements of applied mechanics. The course is specially designed for students of science and engineering above the university intermediate stage, and the authors have sought to reduce pure theory to a minimum in order to develop the fundamental principles upon which the intelligent solution of practical problems depends. The commendable stress on this application of principles rather than their academic aspect is excellently carried out. Even the symbol denoting $\sqrt{-1}$ is given as the more technical j instead of the usual i.

Each chapter is well provided with exercises, many of which are taken from University of London papers, and answers are supplied. The book is a sequel to the authors' more elementary volume, "Mathematics for Technical Students", published in three parts a few years ago.

Technical students will find here a course thoroughly useful to them, and the treatment should stimulate considerable interest in the subject.

Atomic Spectra

By Dr. R. C. Johnson. (Methuen's Monographs on Physical Subjects.) Pp. viii+120. (London: Methuen and Co., Ltd., 1946.) 5*s.* net.

THIS little book endeavours to give a comprehensive, but not too advanced, treatment of the theory of atomic spectra. The subject is presented so as to avoid the need for much mathematical knowledge, and the author, in the words of the preface, has not hesitated to use the picturesque language of the older quantum theory. Modern wave mechanical ideas are conspicuous by their absence.

Most of the monographs in this series are short treatments of limited fields by authoritative writers. This is an attempt to write a small and simple textbook on a large complex subject. Some selection of material is unavoidable; the omission of recent work on line broadening and contours is a pity, though. Dr. Johnson has done well in leaving out much confusing historical background, but clearer definitions of symbols and notation would have helped. We may guess that h and c mean Planck's constant and the velocity of light, but the tendency to use a notation before its meaning is given may be confusing; for example, the description of the spectrum of Mercury (? why capital M) on page 41 as $2^3P_{1,2} - m^1D_2$, etc., before the notation is explained on page 47. The printing is satisfactory and the figures are clear; the index is scarcely adequate.

The book may be helpful to chemists and many who require a pictorial description of atomic spectra; physicists will probably prefer a more modern and more thorough treatment. A. G. GAYDON.

Manometric Techniques and Related Methods for the Study of Tissue Metabolism

By W. W. Umbreit, R. H. Burris and J. F. Stauffer. Chapters on Specialized Techniques by P. P. Cohen, G. A. LePage and V. R. Potter. Pp. vii+198. (Minneapolis, Minn.: Burgess Publishing Company, 1945.) 3.50 dollars.

THIS book has been designed to give the graduate student a working description of the methods used as a routine in the study of tissue metabolism. Only methods which are likely to need the minimum equipment found normally in a biological laboratory such as a respirometer, colorimeter and centrifuge are described. In addition to details of manometric, Thunberg tube and related electrometric techniques, much information is given on the preparation of physiologically important metabolites and particularly on the preparation and estimation of the phosphorylated carbohydrate intermediates. Methods are given for preparing animal, plant and microbial tissues and the homogenate technique is described. The wider use of manometric methods for the estimation of particular metabolites, which with specific enzyme systems utilize or produce gases, such as the estimation of urea with urease and of succinic acid and xanthine by their oxidases, is advocated. A very extensive bibliography follows each of the sixteen chapters.

Biological Field Stations of the World

By Dr. Homer A. Jack. (Chronica Botanica, Vol. 9, No. 1.) Pp. vi+74. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1945.) 2.50 dollars.

BIOLOGICAL stations are perhaps the most important intellectual catalysts for biological research. The informality of work under simple conditions, the mixing of experienced workers and young students, the holiday feeling of meal-times and discussions, all combine to make the atmosphere exhilarating and to generate ideas. It would be interesting to know how many important advances in biology began in summer schools at biological stations. This is about the only information not given by Dr. H. A. Jack in his essay.

It seems a curious subject to write about; like collecting snuff-boxes or fans; but it is useful to have assembled in one place information on the history, administration, facilities and even 'educational philosophy', of biological stations. The most useful part of the work is a directory of 271 biological stations in all parts of the world, as they were operating in 1939. About a quarter of the stations listed are in the United States. There are some omissions; for example, it is not realized that every national park in the U.S.S.R. is a biological station, with an expert scientific staff. E. ASHBY.

RADIO-FREQUENCY HEATING*

By Dr. L. HARTSHORN
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In the last few years the radio-engineer, using his own special technique, has devised two new heating processes, one for metals and one for non-metals. Few recent technical developments have excited more widespread interest among scientific workers, not because any new principle has been established, but because it is recognized that a new tool has come to hand, which in certain respects gives us a command over the forces of Nature that we have not before enjoyed. It may be true that the poor workman always quarrels with his tools; it is none the less true that the scientific workman is always interested in a new one; and physicists and chemists, biologists and metallurgists, as well as engineers, have shown great zest in trying the new tool on their own special problems, particularly their industrial problems. The processes are too young to make possible a considered judgment of their scientific or industrial value: I shall therefore be content to illustrate their special features by a few examples.

When we speak of a heating process, we imply something more than the mere production of heat. The essence of the matter lies in this: we must be able to impart at will an appreciable amount of thermal energy to some particular body. The problem includes not only the production of the energy, but also its transference to the body to be heated; and this transference must be localized and subject to strict control. Two possibilities lie before us: we can generate the energy in the thermal form, and transfer it to the body to be heated in that form, by thermal conduction or convection; or alternatively, we can generate and transfer the energy in some other form, and afterwards convert it into heat in the body to be heated, a process usually described as the absorption of the energy by that body. In the ideal solution of the problem, the heat would appear instantly in the body and nowhere else, in just the amount required and just at the right instant. Both energy and time are involved, and we may say that the process consists essentially in the controlled transference of power, that is, energy per unit time, and its absorption by one particular body, often called by the heating engineer the 'work'. The methods to be discussed here have this feature in common: the power is transferred to the work in the form of electromagnetic vibrations of a frequency lying somewhere in the radio range, say 10 kilocycles to a few hundred megacycles per second, and this is what is implied by the term 'radio-frequency heating'.

The term 'radio' almost inevitably suggests electromagnetic radiation comprising that portion of the spectrum which the radio engineer has taken for his own, say a range of wave-lengths from a few miles to a few millimetres; to avoid misunderstanding it must be emphasized that for the purposes of heating, the power is not employed in the form of radiation: that is to say, in the form of trains of progressive waves such as are employed in broadcasting and television. It is true that such waves are absorbed by both metals and non-metals; and it is because of that very fact that radio-frequency heating is possible; indeed, its peculiar virtues depend very largely on the character and extent of that absorption. But for the purposes of heating, we need to produce a great concentration of power in the 'work'; radiation is the reverse of concentration—it is the dispersal or diffusion of electromagnetic power throughout the universe. When the wave-length becomes short compared with human dimensions, optical technique can be employed for the concentration of radiation, and heating by means of radiation is then possible, provided the work is a reasonably good absorber. The recent developments in 'infra-red heating' are of this character, and one day perhaps the radio-engineer may perform the same feat with his micro-waves; but with the long waves we are now considering this is quite out of the question.

The methods of radio-frequency heating as practised to-day are possible because we can produce great concentrations of power in the form of electromagnetic vibrations in the coils and condensers of oscillatory circuits; we must think of these as stationary vibrations rather than progressive waves. But if one remembers that stationary waves arise simply from the multiple reflexion of progressive waves in a closed space, and that a vibration is no more than a system of stationary waves, we shall see that there is no essential difference in the nature of the energy in the two cases. Both can be visualized as periodic electric and magnetic fields, concentrated in one case and diffused throughout space in the other. Radio-heating—I now feel justified in using this shorter term—consists of the generation of power in these two forms, periodic electric and magnetic fields, its transference to the work, and its absorption by the work.

Generators

The generators used for the purposes of radio-heating are in principle the same as those used for radio-transmission, and we need only consider one form, the valve oscillator. Its construction is a job for the radio-engineer. The principal components are, first, an oscillatory circuit consisting of a coil connected to a pair of metal plates constituting an air condenser; secondly, triode valves; and thirdly, an auxiliary unit, which takes power from the ordinary electric supply mains, and transforms it to high-tension direct current, suitable for application to the valves.

The condenser, when charged by the high-tension current, discharges through the coil in an oscillatory manner, at a frequency determined by the dimensions of the coil and condenser, the commonest sizes of coils and condensers giving frequencies in the radio range. Now what happens in the oscillatory discharge is this: the electropotential energy of the charged condenser, which we represent as an intense electric field between its plates, is transformed into the electrokinetic energy of the discharge current, which we represent as the magnetic field of the coil. Strictly speaking, it is the magnetic field of the whole circuit, but we can usually regard it as localized in the coil, the contribution of the condenser being negligibly small. The condenser having been drained of its energy, the current ceases, the magnetic field dying away and thereby inducing an E.M.F. in the coil, which again charges the condenser, and so on in the familiar way. There is a periodic transformation of the energy of the circuit from one form to the other, potential to kinetic and vice versa, at the natural frequency of the circuit; and these two forms are to a large extent concentrated, one in the coil and the other between the plates of the condenser. Some of this energy is inevitably absorbed

* Substance of a Friday evening discourse delivered at the Royal Institution on February 8.

by all solid bodies in the immediate neighbourhood of the circuit including the coil and condenser themselves, and a little is lost as radiation, so that the oscillation dies down unless additional energy is supplied. This additional energy is supplied by the valves; their control-grids and anodes are connected to the oscillatory circuit in such a way that each valve is automatically triggered by its grid to pass into the circuit a pulse of energy at just that part of the cycle, and of just the amount, that is required to maintain the vibration at a steady level. The ratio of the radio-power to the direct-current power supplied is the efficiency of the oscillator; this can be brought up to about 50–60 per cent, the remaining power being lost as heat in the valves.

It may be well to note at this stage the scale on which radio-heating is practicable. We have read with some satisfaction that during the War the B.B.C. set up the world's most powerful transmitter, delivering no less than 800 kW. of radio-power to the aerial. We have only to express the power transferred in heat units, and divide by the thermal capacity of the 'work', the product of its mass and specific heat, in order to find out the rate at which its temperature will rise, apart from heat losses. In this way we find that if the 800 kW. of power were concentrated into a cubic yard of water at ordinary temperature, it would take about six minutes to bring it to the boil; if concentrated into 1 cu. in. of steel, it would take about 1/16 sec. to bring the whole mass to a uniform temperature of 800° C., say to a cherry-red heat. But outside the oscillator the power is *not* concentrated; it is very thinly spread by the aerial, so evidently there is no danger in wandering through a powerful broadcast. Compared with the 60,000 kW. of an ordinary electric power station, the power is trifling, and it becomes obvious that if quantity and cost are important considerations, radio-power is no competitor of power in the commoner forms: its special virtues lie in its qualities rather than quantity.

We have now to consider the transference of the power to the work and its absorption by the work, and it is here that we find the different treatments for metals and non-metals, a difference that arises from the following facts. First, non-conductors can be permeated by both magnetic and electric fields, but can only absorb power from electric fields. Secondly, good conductors cannot be penetrated by electric fields, but are penetrated to some extent by magnetic fields and absorb power from them very readily. The processes of radio-heating are all developments of these basic experimental facts.

Induction Heating

The transference of power to a metal by the magnetic field is a direct consequence of Faraday's law of induction. Power is the quantity we have to transfer to the work, but for the radio-heating of metals, we always picture the process as the induction of currents, and we often speak of the process as induction, or eddy-current, heating. The power is transferred by the magnetic field exactly as in a transformer, and one of the chief virtues of the radio-frequency is that it makes possible efficient transformer action in simple systems consisting of a very few turns in air, as against the many turns in iron required at low frequencies. Any metal object provides paths of low resistance for the circulation of eddy-currents, and these paths may be regarded as short-circuited turns of a transformer, the coil producing the magnetic field being the primary coil. Very heavy currents are induced by the rapidly fluctuating magnetic field in these short-circuited turns, and the heat is generated by these currents in overcoming the resistance of the metal.

It is a well-known fact that electric currents of radio-frequency are very largely confined to the surface skin of the metal, and the result is that in the radio-heating of metals nearly all the heat is produced in the surface layers of the 'work', the interior remaining cool except in so far as it is heated by thermal conduction from the surface. The concentration of current in the surface can be deduced mathematically from Faraday's law, but we may also describe the whole process as follows. The power is transferred from the generator coil to the metal in the form of the electrokinetic energy of the magnetic field, which freely crosses any space either in air or vacuum. The metal is, however, such a very good absorber that all the energy is absorbed at the surface on which it is incident. The actual depth of penetration can be worked out from a knowledge of the frequency, the resistivity of the metal and its magnetic permeability, so that we can find out what frequency must be used in order to get the energy to penetrate to any desired depth.

The phenomenon has important applications in the case-hardening of steel tools, gear wheels, etc. Since all the heat appears in an extremely thin layer at the surface nearest to the inducing coil, the volume of metal that is heated can be made almost as small as we please: by a suitable disposition of inducing coil, we can transfer all the power available to one portion of the surface, so that the heated portion can be controlled in both area and depth. The concentration of the absorbed power can therefore be made extremely high even with a generator of moderate power. Thus power concentration of, say, 20,000 kW./cu. in. are obtainable with no more than, say, 20 kW. of total power. It is therefore possible with such a generator to heat the surface of a steel tool to a white heat in a second or less, and then by immediate quenching to harden the surface without affecting the main bulk of the material in any way, the whole process being very rapid, subject to precise control, and obviously not in the least likely to cause any distortion of the tool.

Induction heating has also been applied with success to soldering and brazing, the melting and general heat-treatment of metals *in vacuo*, and to many other processes where controlled surface heating is necessary. There are of course many technical details to be considered: the form of inducing coil, and the method of keeping it reasonably cool (water-cooling is usually necessary), the method of coupling the inducing coil to the oscillator in order to ensure the transference of all the power available, or the matching of the load to the generator; but since both the transference and absorption of the power are governed by laws that are well understood, the conditions required for success can usually be predicted from the results of a few trials and a knowledge of the appropriate data for the material to be treated and for the oscillator.

Dielectric Heating

In the induction heating of metals the power is transferred to the metal by the magnetic field, which penetrates the outer layers of the metal, and there induces eddy currents or the circulation of free electrons, which dissipate the whole of the power before

it has penetrated to any considerable depth: the material can be said to be very *opaque* to the flux of energy. The same action must occur to some extent in a dielectric; but it is usually too small to be detected, because these materials do not contain enough free electrons or ions to carry appreciable eddy currents. In other words, the dielectric is *transparent* to the flux of energy, the magnetic field penetrating it completely.

The most characteristic property of a dielectric and the one which distinguishes it from a conductor is that when it is placed in an electric field a definite potential gradient or electric stress is established within it, which stress produces an electric strain or displacement, the material thereby acquiring energy that is distributed throughout its volume. The energy of a charged condenser is a very familiar instance, and we know that every element of volume of the dielectric of such a condenser must be credited with stored energy of a concentration that is proportional to the product of its dielectric constant κ and the square of the field-strength F. It is in this way that the energy is transferred to the material in dielectric heating. We must now consider how it is absorbed, but before doing so we may note that no such transfer occurs to a metal because the field does not penetrate the metal.

The extent to which the energy transferred is absorbed when the field is periodic will depend entirely on the character of the forces controlling the displacement. A displacement of an elastic type, being always in phase with the driving force, gives rise to no net loss or absorption of energy in any number of complete cycles, but a displacement that is retarded by any force of a frictional or viscous character will lag in phase with respect to the driving force, the electric field, and will give rise to a definite loss or absorption of energy in each cycle. It is found in radio practice that for solids and liquids there always is an observable phase difference, δ, between the electric force and displacement, and that within wide limits δ is characteristic of the material and independent of its size and the field-strength F. This can only mean that in every cycle a definite fraction of the total energy put into any element of volume of the material by the field is absorbed, and this fraction turns out to be proportional to $\tan \delta$, which is therefore called, somewhat loosely, the 'power factor' of the material. It follows that the concentration of absorbed power in any element of volume of a dielectric is proportional to $\kappa.f.\tan\delta.F^2$, where f denotes frequency.

This simple relation has several important consequences. First, other things being equal, the concentration of absorbed power, and therefore the heating, is proportional to the frequency and to the power factor of the material. For this reason dielectric heating is usually carried out at as high a frequency as is practicable, and materials of high power factor are selected for treatment if possible. Secondly, if the material is homogeneous and the field can be made uniform, the heat is uniformly distributed throughout the whole of the material. Thirdly, when the field is not uniform, there is a strong concentration of heat in the part of the material occupying the strongest part of the field. Fourthly, when a composite material is treated, the rates of heating of the several components are controlled by their dielectric properties, κ and $\tan\delta$. The great importance of these features of the process will be illustrated by a few typical examples.

Uniform Heating in Depth

Probably the most important characteristic of dielectric heating is that, when a homogeneous material is placed in a uniform field, the heat is distributed uniformly throughout its volume, however thick the material may be. By this process we can, therefore, heat uniformly very thick layers of a material that may be a very poor conductor of heat, an operation that cannot be performed by any other method. Dielectric heating is indeed our only process for the heating of poorly conducting solids in depth.

The following examples illustrate the value of this feature of the process. The first is the moulding of plastics. Heat must be supplied to the moulding material in order to bring it into the plastic condition in which it can flow under pressure into every part of the mould. The heat is commonly supplied by contact with the mould itself, which is heated for the purpose, but the rate at which the heat penetrates the material is restricted by its low thermal conductivity, and this sets a limit to the speed of the whole operation and the thickness of the mouldings that can be satisfactorily made. These limitations are overcome by the dielectric heating of the material immediately before the actual moulding operation. The moulding material, usually supplied in the form of cold-pressed pellets, is placed between the condenser plates of a radio-generator, and in a matter of seconds its temperature throughout rises to the point at which it will flow evenly under pressure. It is then transferred to the press and the moulding operation completed.

Plywood manufacture affords another example. The synthetic resin glues, now largely used, set in say eight hours when cold, but can be made to set in a few minutes by heating to 60°–80° C. Thus the bonding of thin veneers with these glues to form plywood can be greatly accelerated by the application of heat. Considerable pressure is required for the production of good glued joints, and if this is applied by means of a press with heated platens, small thicknesses of wood can be heated by conduction from the platens, but with large thicknesses the operation becomes slow and uneven. By means of dielectric heating, stacks of plywood up to 2 ft. thick can be heated uniformly and bonded in one operation. A thin metal plate in the centre of the stack forms one electrode, and the two platens of the press, which are necessarily connected together by its framework, form the other. A few hundred kilowatts of radio-power is applied to the condenser so formed, and the temperature throughout the mass of 50 cu. ft. or so of laminated wood rises to the point at which the whole bonding operation is completed in a matter of minutes instead of hours.

The application of the method to the rapid production of curved objects in wood will be, I think, sufficiently obvious. The veneers are thin enough to bend very readily, and it is only necessary to bond them together while they are pressed in a jig between rigid surfaces of wood or metal having the required contour.

The process is also of great value in certain drying operations. The drying of poorly conducting materials in large masses in ovens and kilns is always a very tedious business, because the conduction of heat into the centre of the material, and the diffusion of water out of it, are both very slow processes. When dielectric heating is used, the centre of the material is heated instantly and soon becomes hotter than the

outer layers, which are cooled by evaporation and air convection. The relatively high internal temperature produces a correspondingly high internal vapour-pressure which under favourable conditions drives out the water with great speed. I should perhaps mention that the process must be applied with caution to any material that is liable to be damaged by heating to a temperature of 100° C. or less.

Spot Gluing and Welding

Another important quality is the ease and precision with which dielectric heating can be localized. It has been seen that the heat generated is proportional to the square of the electric field strength. If therefore we wish to heat one particular spot of a material only, we merely have to place two small electrodes one on either side of the spot, and deliver the appropriate amount of power to them. The field being almost entirely concentrated in the narrow gap between the electrodes, the heat appears there only. This localized heating provides us with several operations for the jointing of non-metals, analogous to the soldering, brazing and welding of metals.

The process is used in assembling the complex wood structures that go to build up, say, the Mosquito aeroplane. Many such structures consist of thin skins of plywood moulded to the desired streamline contour, and supported and made rigid by girders or bulkheads, also of wood. The veneers from which the plywood is built up and also the supporting members are bonded with synthetic resin glues by means similar to those already considered, which involve the application of considerable pressure while the glues are hardening: only in this way can the full strength of the joint, which, I may say, exceeds that of the wood itself, be obtained. But some means must be provided for tacking the various pieces into their proper positions while the structure is being built up into a form to which the necessary pressure can be applied. Metal screws, pins and staples are often used for the purpose, but they are undesirable since they necessarily weaken the wood at the point at which they pierce it. Spot gluing by localized radio-heating solves this problem. The equipment consists of a small radio-generator which delivers, say, 100 watts of power at 100–200 Mc./sec. through a flexible cable to a pair of small electrodes mounted on a handle shaped like a short gun. The tip of the gun barrel forms one electrode, while the other is a central stud, which when not in use projects a little beyond the end of the barrel, but can be pushed back against a spring. The gun is pressed on the spot to be glued; the inner stud is thus pushed back into the barrel until both electrodes make contact with the surface of the wood. The movement of the stud operates a switch and timing device, which switch on the radio-power to the electrodes for the few seconds required to harden the glue-film at the spot covered by the gun. The electric field is of course most highly concentrated around the surface of the small inner electrode and it is here that the heat is localized. The timing device is adjusted to suit the work in hand. The operation is very simple and rapid.

Thermoplastic material in sheet form can be welded by a somewhat similar technique: both spot welding and seam welding are practised. In seam welding the overlapping sheets are drawn between two small roller electrodes, and the power and speed are adjusted until the power is just sufficient to soften the material in the short time it remains between the two rollers. The pressure of the rollers makes the two soft materials flow together and ensures a good weld, and the joint is cooled by the surrounding air as soon as it emerges from between the rollers. The device can be made to be operated like a sewing machine. Spot welding is performed by means of another gun in which the central electrode has the form of a small roller which is pressed on to the overlapping sheets. Again intense local heating occurs in the strong field immediately surrounding the small electrode, and a good spot weld is made in a second or less.

Selective Heating

One of the most interesting features of dielectric heating still remains to be considered: we can sometimes arrange to supply heat to a mixture of two substances in such a way that nearly all the heat appears in one of them only. We have seen that the concentration of the heat generated within any material is proportional to the product of its power factor, dielectric constant, and the square of the field-strength or voltage gradient. Now although the field between the electrodes may be uniform before the body is inserted, it is not necessarily so afterwards: the relative field strength in the two constituents of a mixture depends on their dielectric constants. However, the variation of this property from one material to another is usually trifling in comparison with the differences of power factor; and in practice, therefore, the concentration of heat in the two constituents of a mixture is roughly proportional to their power factor, and any part of a composite body having a very low power factor remains quite cool in a field which generates considerable heat in parts of high power factor.

A single example will be sufficient to show the value of this property. Take, for example, its bearing on the sterilization of foodstuffs and biological materials generally. If we can find a frequency at which the power factor of the pests we want to get rid of is high, and that of the material to be sterilized is low, we shall have an ideal sterilizing process. An appropriate electric field applied for a very short time would heat the pest enough to kill it without causing any unnecessary and possibly harmful heating of the good material. A very early suggested use for the process was the killing of pests in plant bulbs, and experiments have also been made on grain and other materials. The process is undoubtedly effective in killing the pests; but the extent to which selective heating has occurred is doubtful.

I have here selected those features of radio-heating that are of scientific interest. The industrial value of the process is largely bound up with economic considerations that I have barely mentioned. Radio power is at least ten times as expensive as heat in its cheaper forms, and its industrial use for heating purposes is therefore only justified when it results in a considerable saving of labour, time or floor-space or some such item as is far more costly than mere power in bulk. Nevertheless, it has had some remarkable industrial successes, and no one can doubt that it will have an important place in the industry of the future. It is, however, as a new scientific tool that I have preferred to consider it; a tool that enables us to manipulate thermal energy with precision in circumstances where others fail, and which therefore in some measure extends the range of experimental inquiry.

SOME WAR-TIME BIOLOGICAL BOOKS IN FRENCH

By Dr. JULIAN S. HUXLEY, F.R.S.

A NUMBER of books from France and Switzerland, which have hitherto not been available in Britain owing to the War, have now reached this country. In what follows, some of these are briefly reviewed, in spite of some of them having been published as far back as 1939, as it is felt that British biologists should be made aware of the work that has been going on in other countries during the War.

The French are masters of the art of what one may call the semi-popularization of science—presenting summaries of a subject, which are adequate without being tedious and scientific without being unreadable. Prof. Bertin's book on the eel[1] is an outstanding example of this. Within the brief compass of two hundred pages he brings together all the recent work on eels—historical review, reproduction, life-history and migration, temporary hermaphroditism, mechanisms of euryhaline adaptation, toxic properties of eel-blood, geographical variation and distribution—and demonstrates what fascinating problems the eels set to biologists, and how many of them still await complete solution. There is a brief bibliography, but, unfortunately, no index.

Biologists will be much interested in Bertin's discussion of the toxicity of eel's blood. Its toxicity masks antitoxic properties, for example, in neutralizing both viperine venom and rabies virus, both *in vitro* and through injection into living animals. Bertin, following Phisalix, Peyron and others, concludes that toxicity is a correlate of what may be called tonicity, conferring general resistance on the tissues, and that the utilization of toxicity as a means of defence (toads) or of attack (poisonous snakes and lizards) is a secondary phenomenon.

In his book in the same series[2] Dr. Paulian essays the same task for the beetles. If he is not quite so successful, the subject is largely to blame—the Coleoptera is the largest order in the animal kingdom, including more species than all the other phyla, apart from the Arthropods, taken together. However, the non-entomological biologist, as well as the entomologist, will find his book very useful. It brings together in concise form every aspect of the biology of beetles, including their nutrition (with various remarkable examples of extra-oral digestion), their reproductive physiology (including hypermetamorphosis, neoteny, and the peculiar 'fœto-metamorphosis' of certain Cantharidæ), their often remarkable adaptations (a section which, like the next, is rendered less valuable by the anti-selectionist bias which has of late years infected and impeded the progress of French biology), their speciation (in which Paulian persists in using the now meaningless term *jordanon* or microspecies and does not even refer to subspecies), their evolutionary history, physiological ecology and geographical distribution, their relations with man (including the intestinal troubles caused by the entry of certain coprophagous beetles into the anus). Bibliographic references are given in footnotes, and there is an index.

In a volume of about half the size[3], Dr. Paulian makes a very good job of taking the process of popularization a stage further. "La Vie des Scarabées" is an excellent book for amateur entomologists, biological students and, in general, for that well-known figure, the intelligent layman.

The popular book of Dr. Berlioz on humming birds[4] is, in many ways, rather disappointing. To start with, its scientific value is enormously reduced by the failure to include any bibliography (the absence of an index is also a blemish). Then the author omits mention of what is in some ways the most remarkable property of the group, namely, the faculty of flying backwards, and that other property almost unique among birds, of going into a state of reversible torpidity in unfavourable conditions; and the style is over-elaborate.

In spite of these defects, the book contains much of interest, which is not otherwise readily accessible either to the general biologist or the layman: for example, the sections on communal gatherings of males in the breeding season, on sexual dimorphism, on the adaptive radiation of the family as a whole, and on their geographical distribution and ecology.

Mention must be made of two very beautiful colour plates of particular species, by the author.

A rather different type of popularization is provided by the series entitled "Petits Atlas d'Histoire Naturelle"[5], brought out under the auspices of the Musée National d'Histoire Naturelle in Paris. These booklets, illustrated with admirable colour plates (except those on fossils, which are confined to black-and-white illustrations), deal each with a restricted group of animals. So far the series has covered all the mammals (four booklets), some of the fish (three out of four booklets), all the amphibians and reptiles (two booklets), all the birds (four booklets), some of the insects (three out of six booklets), general entomology (one out of three booklets), fossils (three booklets). A somewhat similar series, published by the same firm, is entitled "Nouvel Atlas d'Entomologie", apparently confined to French species, in twenty booklets; and other booklets on French mammals, crop-pests, and field botany are advertised.

The Petit Atlas provides a remarkable brief conspectus of the general zoology and classification of selected groups, of a type which could profitably be copied by the British Museum (Natural History). The Atlas of French forms should be extremely valuable to amateur naturalists and collectors.

The Palais de la Découverte, under the auspices of the Ministry of National Education, publishes a rather different series of booklets, each concerned with a particular exhibition. Three of these are available for review, one on animal biology, one on the work of the Carnegie Institution of Washington, and one on termites. Here again a new line in the educational work of a museum is being opened up. The Ministry of Education has also produced an excellent general guide to the Palais de la Découverte.

Travellers, evolutionists, historians, anthropologists, plant-breeders, geographers will all welcome the appearance of the book by Drs. Haudricourt and Hédin[6], of the Agronomic Institute and the National Natural History Museum in Paris, since it fills for our days the gap which has yawned ever wider since de Candolle's "Origine des Plantes Cultivées" (1883) began to go out of date.

It brings together the recent data in various fields—the results of botanical exploration, including the special type of study initiated by Vavilov; modern genetics; applied plant-breeding; social anthropology; pre-history; native folk-lore; linguistics—and welds them together to provide an account, both scholarly and readable, of the entire problem, so vital for the understanding of human history, of the origin and development of cultivated plants. Let me

give but one example of the light it sheds. The visitor to West Africa is at once struck by the fact that the great majority of cultivated plants there have been introduced from other continents, and inevitably wonders how the more advanced cultures of the region, such as those of Ashanti, Dahomey or Yorubaland, were able to reach such a high degree of organisation on such a small and meagre range of food-plants. The authors, however, make it highly probable that the negroes, prior to the coming of the white man, used quite a number of other plants, but abandoned their cultivation when more satisfactory crops became available.

The genetic section is not wholly up to date, and the book suffers from the anti-selectionist, anti-adaptationist blight already referred to. These, however, are minor blemishes in a general excellence. There is a brief but valuable bibliography, and a useful index of species as well as one of author and place names. It is much to be hoped that a similar book will soon be forthcoming on the companion subject of domestic animals.

Another volume touching many fields of study is Prof. Sorre's on human geography[7]. It is divided into three books: (1) Climate and Man; (2) The Organic Environment and Human Nutrition; and (3) The Struggle of the Human Organism against the Organic Environment. Book 1, after a general chapter on climate, and one on specific effects of climate on human functions, concludes with a very interesting treatment of "la formation de l'oekumène"—in other words, the cosmopolitan extension of the range of our species.

Much of Book 2 naturally deals with the subject of Haudricourt's and Hédin's volume. While it does not pretend to their up-to-date and detailed knowledge of cultivated plants, it makes up for this by the comprehensive nature of its treatment, relating this and other topics to a broad general theme. This theme is the origin and evolution of what the author calls "the associations of man", that is, the organisms of which he is the centre, including not only domestic animals and cultivated plants, but also the species sought after by hunters and fishermen, the parasites and hangers-on of man and of human societies, and the adventitious flora and fauna. The book concludes with a long chapter on "Géographie des régimes alimentaires".

Book 3 treats of human disease on similar lines, beginning with a chapter on pathogenic complexes, and ending with one on medical geography. There are bibliographical annotations to each chapter, and an excellent index. This is a valuable book which justifies its title in providing a biological basis for human geography.

Ornithologists will welcome another book on Swiss birds by Dr. Noll[8], whose earlier book "Sumpfvogelleben" (1924) on the bird-life of the large nature reserve, the Linthried, gave valuable pictures of the life of various marshland birds. The present book makes no scientific pretensions, but affords pleasant glimpses and often interesting information on Swiss bird-life. Thus Dr. Noll records a tendency of the black redstart in Switzerland to nest more frequently in holes during the last few decades, while the spotted flycatcher, after exhibiting the same tendency for a time, has returned to its original habits. So long as the colony of blackheaded gulls at Kaltbrunn remained small, all the nests were well out of the water, in clumps of rushes; but as it increased in numbers, an increasing number of floating nests were built. About September 10, starlings, though already roosting in the reed-beds, pay farewell visits to the nesting site, where the males may sing. The local swifts learnt that Noll's movements through the marsh meant the rising of numerous insects into the air and they speedily flew down to accompany his passage in search of the food thus provided; but the migrants which arrive in August and stay for a few days have not learnt this fact, and always remain circling high up.

The book contains an appendix of arrival-dates for summer residents, a list of the French vernacular names of all the species referred to, and an index.

Dr. May[9] has given an excellent résumé, approached from a general biological angle, of the evolution and development of the nervous system. After four introductory chapters on the nervous system of lower animals, the remaining eleven are devoted to that of the vertebrates. A brief bibliography is included, confined to general works on the subject, but there is no index.

Dr. May is himself an authority on the developmental mechanics and physiology of the vertebrate nervous system, but has always preferred to look at his subject against the phylogenetic background provided by comparative anatomy. This combination of the experimental-analytic with the comparative-evolutionary approach is a very valuable one in the present state of biology, when separate specialisms are groping towards a new synthesis.

Prof. Bounoure, of the University of Strasburg, has published two volumes on the subject of continuity of the germ-plasm[10,11]. While serving a useful purpose in bringing together a large number of facts bearing on the subject, Prof. Bounoure's work is vitiated by what can only be described as the theological spirit in which it is written. For him germinal continuity is not a problem to be investigated, but a doctrine, or rather a dogma, to be proclaimed and supported. For example, he concludes that "the continuity of the germ-plasm thus appears as a general law of the reproduction of organisms" and does not hesitate to extricate himself from the difficulties arising from the facts of asexual reproduction by asserting that it is not "une véritable reproduction" like sexual reproduction (in spite of the fact that sexual reproduction must have arisen later in evolution than asexual!), but is only "a dissociated ontogeny" (whatever that may mean). In passing, this idea leads him to distort the entire concept of organic individuality. Although the facts drive him to admit that in plants, many tissues, "even though forming part of organs specialized for a vegetative function", are capable of proliferating an entire new organism, he adds that "one cannot absolutely exclude the hypothesis" of the existence of reserve cells in plants—and in any event conveniently excludes the botanical facts from his concluding general discussion.

This is a pity, for the problem of germinal continuity is one of great biological interest. In one sense it is universal, since the genes alone provide full continuity in reproduction, though Bounoure never once refers to the facts of genetics. What we should really like to know is why the separation of germen from soma (using the terms in their ordinary sense, as referring to entire tissues or groups of tissues) is absent in some forms but present in varying degrees of sharpness and precocity in others. On this Prof. Bounoure sheds no light.

Prof. Guyénot's book[12] is the only comprehensive work in French on modern genetics. As such, it is

obviously useful as providing a foundation on which there may arise the long-overdue revival of genetical teaching and research in France. It provides a clear and full account of neo-Mendelism, both in its genetic and cytological aspects, up to the outbreak of war, together with a full bibliography of seventy-four pages (unfortunately arranged by chapters instead of in a single list), and a good index.

What it does not do is to summarize or even mention the extension of modern genetics into the field of evolution, whether in relation to selection, to adaptation, to the formation of species and other natural groups, or to the evolution of gene-complexes or genetic systems, in spite of the fact that this has been one of the most remarkable features of the subject during the past two decades. Thus neither *evolution*, *selection* nor *adaptation* is even indexed.

This omission, though doubtless intentional, is unfortunate. Modern genetics inevitably becomes 'formalist', to use the Russian jargon, unless studied dynamically—in other words, from the point of view of its evolutionary implications; furthermore, the introduction of these implications at once makes the subject much more interesting and stimulating to the student. It is much to be hoped that an equally comprehensive summary of this side of genetics will soon be available in French; meanwhile, Prof. Guyénot has rendered an important service to French biology in having so adequately covered the other half of the ground.

In the same series, Prof. Caullery, the doyen of French zoology, has written a comprehensive volume on the biology of sex[11]. After a general introduction, Part 1 deals with The Sexes and Secondary Sexual Characters, including a chapter on natural hermaphroditism; Part 2 with Sex Hormones; Part 3 with Sex-Determination; and Part 4 with Sex Differentiation and its Anomalies (including gynandromorphism and intersexuality).

Once again the author neglects the evolutionary and adaptational aspects of the subject. Thus the evolutionary function of sex itself is not discussed, and there is no mention of the theory of sexual selection or of the facts of sexual display. Within its field, however, the survey is clear and full, if perhaps not so detailed as that of Prof. Guyénot, and should be of real value to advanced students. There is a moderately full bibliography of twenty-one pages (arranged by chapters) and an index.

Dr. Chopard's large work[14] is the first volume of an important new series, the Faune de l'Empire français. It contains a systematic account of the "Orthopteroidea" (the author's name for Orthoptera in the extended sense, including Dictyoptera and Dermaptera as well as Orthoptera *sensu stricto*) of North Africa and the adjacent regions. Though it is obviously an important contribution, its value is considerably diminished by the inadequacy of its 'ethological' notes, and the total absence of any attempt at relating the large body of data to general principles—of geographical distribution, ecology, adaptation, sexual selection, evolutionary speciation, etc. One must further admit that even if the author had attempted any such task, he would have been ill-equipped for it, since he is one of those all-too-numerous representatives of French biology who lean backwards in the attempt to minimize the importance of adaptation and to avoid what they are pleased to call 'finalist' interpretations of biological phenomena. In this attempt, they often display an attitude which one is driven to stigmatize as biological illiteracy. What, for example, is one to think of Dr. Chopard's remarks on procryptic resemblance, both general ('homochromie') and special (which he persists in calling 'mimétisme')? Thus on p. 11 he writes, "La valeur protectrice de l'homochromie et du mimétisme est fort discutée et, dans bien des cas, elle semble très douteuse. En ce qui concerne l'homochromie, on trouve par contre une explication très satisfaisante du fait lui-meme dans l'action exercée par la teinte du substrat sur ces insectes au moment de la mue".

How long will it be before specialists in different branches of biology grasp the old and elementary principle that 'explanation' in biology operates of necessity on three levels: the physico-chemical; the individual, whether physiological or ontogenetic; and the evolutionary-historical, or phylogenetic; and that to 'explain' a phenomenon on one level has nothing to do with the other levels. If general cryptic resemblance has a function, this function may equally well be based mainly upon a genic mechanism (historical explanation) under the influence of natural selection in the past, or mainly upon a physiological mechanism in the effect of background on coloration at the moult (individual ontogenetic explanation). Chopard's suggestion is rather like saying that spectacle lenses made of plastic material cannot have the function of helping defective vision because they are not made of glass as in the past.

Again, apropos of the 'death-feigning' of stick-insects (and of the curious phenomenon of 'auto-hæmorrhœa' or reflex bleeding exhibited by various Orthoptera when handled), Chopard maintains that if it can be established as a reflex action, it *therefore* cannot be an adaptation! In order to avoid any charge of misrepresentation, I will quote his actual words (p. 11): ". . . on a longtemps interprété ces faits [of 'death-feigning' by immobility] comme un moyen de défense. . . . On sait aujourd'hui qu'il s'agit d'un reflexe causé par certaines excitations, en particulier par une legère secousse". This is like saying that because a train starts ('reflexly') in response to the guard's whistle and flag, we need not concern ourselves either with its function (of taking people to a particular destination) or of the historical origin of the machinery (locomotive engine, etc.) required to perform that function.

I have dwelt on this point at some length because, until taxonomists, comparative physiologists and ecologists become properly seized of the modern proof by geneticists that natural selection is an omnipresent, powerful and flexible agency, leading inevitably and universally to adaptations of every kind, the value of their work to general biology will be severely impaired.

Dr. Rode has published two small volumes in the same series[15] on the ungulates of tropical Africa. There is little general discussion, but the work should be useful to those in the African colonies and as a compendium of facts. Some of the facts raise questions of general biological interest; for example, the distribution of the direction of the horn-spiral among antelopes, and that of the presence and degree of development of the horns in the two sexes. When the geographical variation of various African ungulates is more fully known, this too should permit of valuable conclusions; meanwhile, it is of interest to find a distinct subspecies of hippopotamus confined to the Bornu-Chad area, in spite of the type subspecies extending across the continent from Senegal to Abyssinia.

Dr. Rode is insistent that the more interesting

larger ungulates, including giraffe, rhinoceros and elephant, are doomed to disappear from the French colonies unless special measures are taken for their protection. Even the hippopotamus has been seriously reduced in numbers, and more in the French areas than elsewhere.

Complementary to Rode's volume is that of Dr. Gromier[16] on African big game. Dr. Gromier is an excellent representative of the sportsman-naturalist type, who studies and photographs as well as shooting his quarry. After a general introduction which includes various valuable practical suggestions, he treats at some length of the African elephant (which, he considers, has the right to the title of 'King of Beasts'), with shorter sections on rhino, hippo, lion, buffalo, eland, giraffe, and both sub-species of gorilla. The book is illustrated with numerous photographs by the author, some of considerable interest, and by plates of footprints of the animals described in the text and of some others.

The African elephant is a species of extremely wide ecological tolerance, combined with an interesting plasticity of behaviour. Thus Dr. Gromier says it uses its tusks for digging only in dry areas. The eland, giraffe and lion have a lesser but still very considerable range of ecological tolerance.

The individual variability of elephants is very unusual among animals (in this respect the species bears a resemblance to our own). Among the many variants Dr. Gromier notes is one remarkable individual, the tusks of which were crossed in front of the trunk after the fashion of some of the mammoths. He unfortunately refrains from giving the measurements of the largest specimen he shot, "for fear that he might have been mistaken"! He notes, however, that they exceeded those of the animal recorded by Foa, which was 3·69 m. (just over 12 ft.) at the withers.

Though both the lion and the giraffe are often to be found in thorn-bush, the latter takes little account of thorns (on account of its thick hide), whereas to the lion they are formidable obstacles. Dr. Gromier mentions the prevalence of mutual licking in giraffes —an interesting social habit, reminiscent of the trophallactic mutual licking of termites. He considers that this has arisen through the inability of the giraffe, owing to the length of its neck, to lick its own body clean—a fact which he thinks is also the cause of their pronounced smell.

The alimentary demands of the gorilla may be appreciated by the fact that, in two specimens, Dr. Gromier found in the stomach the remains of a single meal of about forty bananas, together with other materials. Gorillas also show more marked individual variation than do most wild species (for example, in colour); as do lions. The two subspecies of gorilla differ interestingly in social habits; the forest race lives in small family bands, usually with only one (or two) adult females, while the mountain race forms extended family groups of twenty to thirty individuals, including several females and young males.

He gives some interesting examples of variations in rhinoceros horns, including some which are quite straight and others which are curved forwards, indicating a reversal of the normal growth-gradient in this region.

For those who like a macabre flavour to their ecology, I recommend Dr. Gromier's account of the "orchestre scabreux et scatologique" resulting from the pressure of gas inside a decomposing rhinoceros carcass. "Les moindres fissures ou érosions de la peau jouaient leur petit air de flûte, les cuivres étaient tenus bruyamment par les anses intestinales qui s'échappaient des voies naturelles, et un morceau du colon énorme, qui avait réussi à passer par le sphincter, tonitrua un air de trombone triomphant". The observations of the field naturalist can add both realism and surrealism to those of the systematist and the anatomist!

[1] Les anguilles: variation, croissance, euryhalinité, toxicité, hermaphroditisme juvénile et sexualité, migrations, métamorphoses. Par Léon Bertin. (Bibliothèque scientifique.) Pp. 218+8 plates. (Paris: Libr. Payot, 1942.) 50 francs.

[2] Les coléoptères: formes, mœurs, rôle. Par Dr. Renaud Paulian. (Bibliothèque scientifique.) Pp. 396 (14 plates). (Paris: Libr. Payot, 1943.) 125 francs.

[3] La vie des scarabées. Par Dr. Renaud Paulian. (Histoires naturelles, 5.) Quatrième édition. Pp. 234. (Paris: Libr. Gallimard, 1944.) 95 francs.

[4] Les colibris. Par J. Berlioz. Pp. 198. (Paris: Libr. Gallimard, 1944.) n.p.

[5] (Paris: Boubée et Cie., 1942 and later.) n.p.

[6] L'Homme et les plantes cultivées. Par André G. Haudricourt et Louis Hédin. (Géographie humaine, 19.) Huitième édition. Pp. 234+16 plates. (Paris: Libr. Gallimard, 1943.) 110 francs.

[7] Les fondements biologiques de la géographie humaine: essai d'une écologie de l'homme. Par Prof. Max Sorre. Pp. 440. (Paris: Armand Colin, 1943.) n.p.

[8] Oiseaux de mon pays. Par H. Noll. Pp. 182. (Neuchâtel et Paris: Delachaux et Niestlé S.-A., 1939.) n.p.

[9] La formation du système nerveux. Par Raoul-Michel May. (L'Avenir de la science, 20.) Pp. 302+45 plates. (Paris: Libr. Gallimard, 1945.) 330 francs.

[10] L'Origine des cellules reproductrices et le problème de la lignée germinale. Par Prof. L. Bounoure. (Collection des Actualités biologiques.) Pp. xii+272. (Paris: Libr. Gauthier-Villars, 1939.) 120 francs.

[11] Continuité germinale et reproduction agame. Par Prof. L. Bounoure. (Collection des Actualités biologiques.) Pp. iv+84. (Paris: Libr. Gauthier-Villars, 1940.) 56 francs.

[12] L'Hérédité. Par Prof. Émile Guyénot. (Encyclopédie scientifique: Bibliothèque de biologie générale.) Troisième édition. Pp. 717. (Paris: G. Doin et Cie., 1942.) n.p.

[13] Organisme et sexualité. Par Prof. Maurice Caullery. (Encyclopédie scientifique: Bibliothèque de biologie générale.) Pp. 342. (Paris: G. Doin et Cie., 1942.) n.p.

[14] Faune de l'Empire français. 1: Orthoptéroïdes de l'Afrique du nord. Par Lucien Chopard. Pp. 450. (Paris: Libr. Larose, 1943.) 300 francs.

[15] Faune de l'Empire français. 2: Mammifères ongulés de l'Afrique noire. Par Paul Rode. Première partie: Famille des bovidés (buffles, antilopes, gazelles). Pp. 124. n.p. Deuxième partie: Tragulidés, giraffidés, suidés (phacochère, potamochère, hylochère), hippopotamidés (hippopotame), périssodactyles (rhinocéros), proboscidiens (éléphant), hyraciens (damans). Pp. 125–212. n.p. (Paris: Libr. Larose, 1943–1944.)

[16] La vie des animaux sauvages de l'Afrique. Par Dr. Émile Gromier. (Bibliothèque géographique.) Pp. 344+36 plates. (Paris: Libr. Payot, 1938.) 100 francs.

GENETICS OF THE MICROFUNGI

By Prof. C. T. INGOLD

At its morning meeting in London on December 19, 1945, the Society for General Microbiology, with Sir Alexander Fleming in the chair, discussed the question of "Variation of Cells having Bi-parental Inheritance", and the papers and discussion dealt largely with the genetics of the microfungi. After a brief survey of reproduction in the microfungi by the present writer, Prof. Ö. Winge, of the Carlsberg Laboratory, Copenhagen, dealt with his genetical work on yeasts, which has revolutionized our ideas of these organisms. He was followed by Dr. D. G. Catcheside, who discussed the importance of the heterothallic Ascomycetes as tools for the geneticist.

Apart from the first discovery of conjugation in a fungus by Ehrenberg in 1818, perhaps the greatest advance in the study of sexuality in these organisms was due to Blakeslee, who in 1904 described the phenomenon of heterothallism in the Mucorales. This opened the way for experimental breeding, and in 1925 Burgeff[1] succeeded in mating *Phycomyces Blakesleeanus* with *P. nitens* and obtaining zygospores which germinated to give a hybrid—the first true

interspecific hybrid to be produced experimentally in fungi. However, members of the Mucorales are unlikely to become popular with the geneticist, since germination of the zygospores is usually difficult, the nuclei are so small that the fundamental cytological facts of the life-cycle are still in doubt and the multinucleate condition of the sporangiospores introduces possible complications.

In 1914 Egerton[2], working with *Glomerella*, reported heterothallism in Ascomycetes, and since that time many more examples of this phenomenon have come to light in that group. However, it soon became apparent that the nature of heterothallism in Ascomycetes was not quite analogous to that in Mucorales. In Mucorales, although there is usually no consistent difference in size between the two cells which fuse to form the zygospore, it is a reasonable theory that the difference between + and − strains is essentially one of sex. This explanation does not hold for the Ascomycetes. In *Ascobolus magnificus*, for example, apothecia are produced only where + and − mycelia meet, but each is hermaphrodite, producing well-defined male and female organs. Thus the difference between + and − is not a sexual one. Each strain is bisexual, but self-incompatible.

In Ascomycetes the asci are borne on ascogenous hyphæ which usually arise from the female organ. In the ascogenous hyphæ the nuclei occur in pairs and, in heterothallic species, it seems likely that each pair consists of a + and a − nucleus. The bi-nucleate ascus-initial cell likewise has a + and a − nucleus.

The cytology of ascus development has given rise to considerable controversy. Most mycologists and cytologists would probably now agree that the two nuclei of the ascus-initial are haploid, that these fuse to form a diploid nucleus, that the two nuclear divisions which then occur constitute meiosis, and that the four haploid nuclei then undergo a final mitosis giving eight haploid nuclei, around each of which a spore is organised. This is the only picture of ascus development which is supported by genetical evidence.

Because we know where meiosis occurs and because of the orderly arrangement of the eight spores in the ascus, the heterothallic species of Ascomycetes are valuable tools in the hands of the geneticist, especially because the products of a single meiosis, being conveniently wrapped up in an ascus, can readily be isolated and studied.

Starting with the pioneer work of B. O. Dodge on *Neurospora*, much attention has been given to the genetics of this genus in recent years, and it bids fair to become as notable a genus in the history of genetics as *Pisum*, *Drosophila*, *Zea* and *Datura*. In heterothallic species of *Neurospora*, Lindegren[3] has made important studies on the segregation of the gene pair, + and −, in the ascus. There are always four + and four − spores. If segregation occurs at the first division of meiosis, the four upper spores are + and the four lower −, or vice versa, but if segregation occurs, following a cross-over, at the second division of meiosis, then four other arrangements are possible. Lindegren found that all these are realized. Other allelomorphic pairs, besides + and −, have been studied in *Neurospora* and these have been found to segregate in the same manner, half the spores of the ascus carrying one gene and the other half its allelomorph. A specially beautiful example was described by Zichler[4] in *Bombardia lunata*. In a cross between a dark-spored and a light-spored variety the asci in the resulting perithecia had each four dark and four pale ascospores. All six possible arrangements of these spores in the ascus were encountered, and Zichler gave extensive data of the number of asci exhibiting each pattern of spore-distribution. His data have recently been carefully analysed by Catcheside[5], who finds that the gene for dark spores, whether segregation occurs at the first or second division of meiosis, tends to pass more often to the apical than to the basal end of the spindle. The solution of the cause of this curious 'polarized segregation' may throw additional light on chromosome and cell dynamics.

A great landmark in the genetical study of the microfungi was Prof. Ö. Winge's discovery that species of *Saccharomyces*, far from being apogamous, exhibit a definite diplophase and haplophase. The beautiful papers on the genetics of yeast which have been issued from the Carlsberg Laboratory during the past ten years have already become classics of mycological literature*. Winge[6] found that when an ascospore of *Saccharomyces cerevisiæ* germinates, it buds to produce small round haplophase cells. Sooner or later these may fuse in pairs, and from each fusion cell a large oval diplophase cell buds out which can originate a giant colony of diploid cells. He further found that most naturally occurring yeasts are highly heterozygous, with the result that the four colonies arising from the four isolated spores of an ascus are quite unlike and all different from the parent colony. The giant colonies formed by yeasts of different genotype are often strikingly different and the great beauty of some of them is illustrated in the fine plates of the Carlsberg papers. In the strains of yeast investigated by Winge, homothallism appears to have been the rule and the haplophase was short-lived. However, in recent years another school of yeast genetics has developed in America under Lindegren[7], who reports heterothallism—though not very strict heterothallism—in the strains of yeast with which he worked. He found that more or less stable colonies of small-celled haplophase yeast could be produced from single ascospores which showed little tendency to give rise to the diplophase.

A big step forward in the study of yeast genetics was made by Winge[8] when he succeeded in producing a hybrid between *Saccharomyces ellipsoideus* and *S. validus* by placing an ascospore of each species side by side. The two spores fused and from the fusion cell a hybrid bud grew out from which a hybrid colony originated. The hybridization of yeasts offers great possibilities in the industrial field.

Winge[6] also studied mutations in yeast. A colony arising from a uninucleate haploid ascospore might be expected to remain true to type. However, even in such a colony sectors of a new type may occur, presumably as a result of gene mutation.

The Ascomycetes with their illegitimate cousins in the Fungi Imperfecti make up the vast majority of the microfungi. On the other hand, the Basidiomycetes are mainly large forms with the very important exceptions of the rusts and smuts. It is interesting to note that most rusts and smuts appear to be heterothallic. In recent years much attention has been paid to the genetics of smuts, and interspecific hybrids have been produced. In rusts, different physiological races have been crossed and as a result new races have arisen. In the life-cycle of the black stem rust of wheat due to *Puccinia graminis*, the barberry has developed a new significance. It is no longer to be regarded merely as

* E. R. Sansome has given a recent review of yeast genetics in *Nature*, **157**, 52 (1946).

an alternate host on which the rust gathers its strength for its attack on the wheat; it is also a common ground on which the various physiological races of the rust can meet and hybridize with the production of new races.

In 1938 Hansen[10] described the 'dual phenomenon' in Fungi Imperfecti and explained this by the hypothesis of heterokaryosis. In *Botrytis cinerea*, for example, the conidium has several nuclei and it is suggested that they are not necessarily genetically alike. When such a spore gives rise to a colony a sector may develop differing from the rest. This sector may have arisen from a branch which, instead of having a mixture of nuclei of two or more different genotypes, has received nuclei of only one. It is well known that, in Nature, such a fungus as *Botrytis* occurs as a number of strains. When two strains meet, anastomoses (vegetative fusions) occur freely, and through these the nuclei can pass from one strain into the other, thus producing the heterokaryotic condition. The freedom with which nuclei can move through a mycelium of septate cells has been emphasized by Buller[11], who directed attention to the fact that the central pore existing in the cross-wall of higher fungi allows free streaming of protoplasm and transport of nuclei from cell to cell.

This peculiar heterokaryotic condition which may arise in the higher fungi offers interesting possibilities to the geneticist, in spite of the fact that no karyogamy is involved. The question has been discussed by Pontecorvo and Gemmel[12,13] in recent contributions to *Nature*.

Recent work by Beadle and Coonradt[14] on heterokaryosis in physiological mutants of *Neurospora* is especially interesting and suggestive. For the growth of fungi certain vitamins are necessary. Some fungi are capable of synthesizing some or all of these, others can grow only if the necessary ones are provided. Both vitamin B_1 (thiamin) and B_6 (pyridoxin) are necessary for the vegetative growth of *Neurospora*. Beadle and Coonradt obtained a strain which could synthesize B_1 but not B_6 and another which could make B_6 but not B_1. Neither would grow by itself on a standard basal medium. When, however, macroconidia belonging to the two strains were sown together, vegetative fusions occurred and the heterokaryotic mycelium, capable of synthesizing both B_1 and B_6, grew freely.

Something is now known of the genetical causes of the instability of pure cultures originating from single cells or single spores. In yeasts genetical segregation may occur, in cultures started from a single cell, at ascus formation. In conidial fungi with multinucleate spores heterokaryosis may be the cause of variation. Finally, in any cell and at any time gene-mutation may occur.

The genetics of fungi is an exciting and rapidly expanding subject, but one must bear in mind the warning words of Albrech von Haller more than two hundred years ago when he described fungi as "a mutable and treacherous tribe".

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OBITUARIES

Prof. J. Stanley Gardiner, F.R.S.

JOHN STANLEY GARDINER, emeritus professor of zoology in the University of Cambridge and one of the outstanding figures in British zoology, died suddenly on February 28 at the age of seventy-four. His research career began in 1896 when he took part in the Royal Society's well-known expedition of Funafuti; from then onwards he was recognized as an authority on the distribution of marine animals in general and on the madreporarian corals in particular. Between 1897 and 1909 he organised and led three major expeditions to the Indian and Pacific Oceans, each of which threw considerable light on the broad relationships between the physical and biological aspects of oceanography. Perhaps the most interesting of these expeditions was that to the Maldive Archipelago, for it led to the theory that a large land mass could be eroded to a depth of about 150 fathoms, thus giving rise to a submerged plateau which would later provide a foundation for coral reefs. From 1909 onwards, university duties prohibited further expeditions, but at least three other major projects owe much to Gardiner's inspiration and active support: the Suez Canal expedition under Munro Fox (1924), the Indian Ocean expedition (1933) under Seymour Sewell and the Lake Titicaca expedition under H. C. Gilson (1937). Gardiner's work was recognized by his election to the Royal Society at the relatively early age of thirty-six, and in later years he received the Agassiz Medal of the U.S. National Academy of Science, the Gold Medal of the Linnean Society, and the Darwin Medal of the Royal Society. He delivered the Lowell Lectures at Harvard in 1930.

After each of his expeditions, Gardiner returned to Cambridge to play an active part in college and university life. He became a fellow of Caius in 1898, dean in 1903 and senior proctor in 1907. In 1909 he succeeded Adam Sedgwick as professor of zoology and for the next twenty-eight years remained in residence in the University. He was, above all else, a man of wide scientific vision, and his influence was felt far beyond the limits of his own research interests. He was in no sense a physiologist, but he saw clearly that the study of animal form could acquire new significance when considered in relation to function. As head of his Department at Cambridge, he did all in his power to weld morphology and physiology into one indivisible science. Between 1909 and 1914 his own lectures on "The Principles of Zoology" gave to students this new point of view, but perhaps of even greater significance was Gardiner's ability to gather round him men of inspiring personality. In 1910 Leonard Doncaster and Cresswell Shearer joined his staff, and these with Gardiner formed a nucleus around which advanced students rapidly gathered.

On the outbreak of war in 1914, Gardiner shouldered an extremely heavy burden of teaching, but nevertheless devoted a great deal of energy to the organisation of fishery research, of which he acted in the official capacity of director of scientific investigations until 1920. At the end of the War of 1914–18, Gardiner, with characteristic foresight and generosity, gave to each returning member of his staff a full year's freedom from teaching, and he encouraged them by every means in his power to develop their research interests. During the next fifteen years he continued to foster the functional outlook, but, at the same time, developed other aspects of zoology, notably ento-

mology and hydrobiology. Much new material was introduced into the teaching and inevitably some of the older topics were omitted. For this Gardiner was, at times, sharply criticized by some of his colleagues in other universities, but by 1930 he had the satisfaction of knowing that his Department was the recognized centre of functional morphology in Great Britain. It received large endowments and its present laboratories are the fruit of Gardiner's endeavour.

It would be wrong to regard Gardiner's great services to zoology as the result of careful and precise planning. It was not so. It was due to the width of his scientific vision and his ability to focus his attention on essential points. He never became immersed in detail, but would follow up an idea with vigour and enthusiasm. These were the qualities he looked for in others, and if Gardiner were satisfied on these two points, no young man ever approached him in vain, however strange his project might be at first sight. He never forgot that one of the primary objects of a university is to train young men to think for themselves and not to burden their memories with factual knowledge. If an exposition of somewhat arid facts were unavoidable, Gardiner would inject a leaven of speculation which, at times, might be somewhat disconcerting—as also was his famous examination question: "Discuss any zoological problem which is of particular interest to yourself".

Not the least of Gardiner's contributions to Cambridge zoology was the development of the Balfour Library. Starting with the books bequeathed by Francis Maitland Balfour, Gardiner built it up into one of the finest zoological libraries in Britain, and it is fitting that his portrait should hang over its doorway.

Gardiner was elected a trustee of the British Museum in 1931 and a member of the Standing Commission on Museums and Galleries in 1942. For these appointments he was peculiarly well fitted, for in addition to his scientific knowledge, he had a deep sense of appreciation of water-colour painting, his own collection being of considerable interest. Gardiner's hours of leisure were spent in his garden, in yachting or in fishing. During his later years he took relatively little part in the administrative affairs of his College or of the University. He belonged to a generation of scientists who regarded administration as the servant of learning. The work of a committee warranted respect in so far as it facilitated work in the laboratory and no further; if it failed in this respect it was essentially something to be laughed at or ignored. In administrative circles Gardiner's particular genius was not always readily appreciated; but any conception of Gardiner as an indifferent administrator would be false. When he was sufficiently interested in a problem, his facts were accurate and his exposition concise.

Gardiner was elected to his professorship under statutes which did not involve retirement at a specific age, but he placed himself voluntarily under an obligation to retire in 1937. After a brief holiday in Cyprus, he returned to Cambridge full of vigour and devoted himself to picking up the threads of the *Sealark* expedition and to re-organising sections of the Balfour Library. His health failed suddenly about two years ago.

Gardiner was a leader in the sense that he broadened the field of biological research. Above all, however, he was an outstanding personality capable of inspiring in others the enthusiasm and confidence necessary for them to tackle difficult problems however remote these might be from Gardiner's own immediate interests. Perhaps the secrets of his success were that he never grew old in mind or spirit, and never took himself or others too seriously. He derived not a little amusement by disguising the real point of a conversation to the very last moment; to earnest-minded students or colleagues this was often disconcerting, but he did not do this at moments of crisis. When a situation demanded action, Gardiner was quick and effective; when help was needed Gardiner never failed to respond. He endeared himself not only to colleagues and assistants in the laboratory, but also to each generation of students in turn. The crayon drawing by Ronaldson which hangs in the Balfour Library reflects faithfully the spirit of a distinguished scientist and a most unselfish man.

J. GRAY.

Prof. F. A. Cavenagh

BY the death of Prof. F. A. Cavenagh on April 21 the academic study of education in Great Britain has lost one of its outstanding exponents. Many generations of teachers whom he trained will also regret the passing of an inspiring leader, a wise counsellor and a firm friend.

Francis Alexander Cavenagh was born in 1884 and was educated at University College, London, of which he afterwards became a fellow. He was also a student, under Sir Percy Nunn, at what was formerly known as the London Day Training College (now the Institute of Education). In 1909 he obtained the M.A. degree with distinction in classics. He then served as a schoolmaster, first at Cheltenham Grammar School and afterwards at the recently founded King Edward VII School, Lytham. In 1912 the Lytham headmaster, Mr. Bompas Smith, went on to the University of Manchester as professor of education and two years later Cavenagh was appointed as a lecturer on his staff. Cavenagh's work at Manchester was interrupted by a period of service in the Artists' Rifles and the R.G.A., and in 1919 he acted as Area Education Officer, H.Q. London District, and as lecturer at the War Office School of Education, Oxford. In 1921 he became professor of education at University College, Swansea. He worked up the Department there, almost single-handed at times in the early days, and rapidly made his mark as one of the most distinguished professors of education in Great Britain. In 1933 Prof. Dover Wilson temporarily relinquished the chair of education at King's College, London, in order to undertake a year's full-time research, and Cavenagh took charge of the Department there; but at the end of the year he was appointed the first professor of education at Reading, where he remained until 1937. He then returned to King's College as University professor of education.

Cavenagh's tenure of the King's College professorship coincided with a time of great national difficulty. Soon after the outbreak of war his Department was evacuated to Bristol; but the conditions there were no less trying than in London. Cavenagh had not only to cope with the administrative problems arising from evacuation, but he also threw himself wholeheartedly into A.R.P. work; and there is little doubt that his exertions and devotion in this service undermined his health. When King's College returned to London there was still a period of flying bombs and rockets to be endured, and Cavenagh continued to give himself unsparingly until his health finally broke down.

As an educationist Cavenagh had a wide range of interest. His philosophic outlook was early evidenced by his study of "The Ethical End of Plato's Theory of Ideas" which was published in 1909. His educational views were based on carefully thought-out principles; but he was no mere theorist. He was particularly interested in adult education, a member of the council of the British Institute of Adult Education and editor of its journal. He kept closely in touch with current educational developments and problems, and his criticism was always both wise and constructive. His contributions to the "Year Book of Education" and to the *Journal of Education*, as well as to other educational periodicals, were scholarly, judicious and authoritative. He had, perhaps, a particular interest in nineteenth-century English education, and this is evidenced by his admirable editions of the educational writings of James and John Stuart Mill, and of Herbert Spencer. Large-hearted, understanding, sincere, he leaves a place among his colleagues and friends that will be hard to fill.

H. C. BARNARD.

We regret to announce the following deaths:

Mr. E. G. Boulenger, formerly director of the Aquarium of the Zoological Society of London, on April 30, aged fifty-seven.

Dr. S. Flexner, For.Mem.R.S., emeritus director of the Rockefeller Institute for Medical Research, New York, on May 2, aged eighty-three.

Count Hermann Keyserling, author of "The Travel Diary of a Philosopher" and works on the psychology of nations, on April 26, aged sixty-five.

General Georges Perrier, member of the Section of Geography and Navigation of the Paris Academy of Sciences, formerly general secretary of the International Union of Geodesy and Geophysics, aged seventy-three.

NEWS and VIEWS

Retirement of Dr. F. H. A. Marshall, C.B.E., F.R.S.

In 1943 Dr. F. H. A. Marshall officially retired from the readership in agricultural physiology in the University of Cambridge on account of age, but he consented to carry on with the duties during the war period. These duties he relinquished at the beginning of 1946. By the production of his book on "The Physiology of Reproduction" in 1910, and the subsequent edition in 1922, Marshall laid the foundations for much scientific work on this subject both in Great Britain and in the United States: the discovery of the hormones of the anterior pituitary and much of the modern science of endocrinology was stimulated by the publication of his book. In addition, as reader in agricultural physiology at the School of Agriculture, Cambridge, he initiated the application of the science of physiology to the problems of animal production and has stimulated and encouraged many generations of agricultural students to study the animal and the way it works, to the great advantage of the animal-breeding industry. His work has been recognized by a number of academic distinctions and by the award of the Royal Medal of the Royal Society in 1940. It is felt, however, by many of his friends, that some more personal tribute should be paid to him on this occasion, and a fund is, therefore, being set up at the School of Agriculture, Cambridge, in order to make him a presentation, a part of which it is hoped to use for a portrait.

Physical Society and the Société Française de Physique: Holweck Prize and Medal

Early in 1945 Prof. E. N. da C. Andrade, then president and now foreign secretary of the Physical Society, on behalf of the Council issued to fellows and friends of the Society an appeal for contributions for the foundation of a prize as a mark of their admiration for, and sympathy with, their French colleagues who had worked strenuously under great difficulties during the German occupation, and as a memorial to Dr. Fernand Holweck, the distinguished director of research at the Institut du Radium in Paris, who had died at the hands of the Gestapo, and to other French physicists who met their deaths or suffered privation. The sum collected has enabled the Physical Society to establish a Holweck Prize, to be awarded annually for ten years alternately to a French and British physicist for distinguished work in experimental physics, the presentation to the French winners to be made in London and those to the British winners in Paris. The scheme evoked lively interest and profound gratitude in French circles, and the Société Française de Physique, with which intimate co-operation in the selection for the Prize has been sought, has founded a Holweck Medal which is to be presented to each recipient of the Holweck Prize.

The first award of the Holweck Prize has been made to Prof. Charles Sadron, of the Institute of Physics, University of Strasbourg, in recognition of his many researches, notably those on the mechanical properties of liquids. He is, fortunately, one of the survivors of the horrors of the ill-famed Buchenwald concentration camp. The presentation will take place at a meeting of the Physical Society at the Royal Institution on May 16, in the presence of His Excellency the French Ambassador, and the president and other distinguished representatives of the Société Française de Physique; it will be followed by a discourse by Prof. Sadron on "Some Physical Properties of Long-chain Molecules".

University Entries for 1946–47

In a statement made in the House of Commons on April 30, Mr. G. A. Isaacs, Minister of Labour and National Service, announced the conditions which are to govern entry of students to universities in Britain for the year beginning October 1946. They fall into three sections: preference will be given to those who have served in the Armed Forces or in civilian work of national importance; places in all subjects are to be filled; and those granted deferment from military service will be called up on the completion of their university courses. Universities can apply for release from the Forces of scholars and highly promising students in release groups 1–55, and they may also admit students who have completed three years of national service; the latter will be granted continued deferment to enable them

to complete their studies. Not more than 10 per cent of the places available may be filled by those of age 18–19 recommended for deferment by joint recruiting boards, and other suitable students of that age-group. Medical, dental and veterinary students will in future be dealt with in the same way as other students. Women's colleges are being asked to give preference to those who have been on war service. It is hoped that universities generally will not accept boys younger than eighteen. Mr. Isaacs added that these proposals have been accepted by the vice-chancellors of the universities.

For many months past, this announcement has been anxiously awaited by those responsible for university development in Britain. Since Mr. Isaacs stated that the vice-chancellors of the universities generally approve the scheme, it would seem that university needs have, in the main, been met. It is clearly right that those whose courses have been interrupted, and those who would have entered the universities had the War not intervened and diverted them to some form of national service, should have preference in the competition for places. But without studying the data on the possible number of entries, it is not possible to assess the wisdom of fixing on the figure of 10 per cent for the maximum number of places available for schools. It is probably all to the good, however, that the entry of youths of less than eighteen should be discouraged; they will thus be able to enter the universities at a more mature age and with a period of service intervening between their school and university studies. The proposal to open up all subjects again will be widely welcomed; there has been a serious break in the output of students of the humanities which is likely to show its effect in the teaching profession for some years to come, and indirectly it has militated against that broad cultural education which should characterize university training.

Series of Polynomials

In many problems of pure and applied mathematics it is required to express a given function in terms of certain polynomials, such as those associated with the names of Legendre and Hermite. The general theory of all polynomials that can be used in this way engaged the attention of several mathematicians, including Prof. J. M. Whittaker of Liverpool. In the dark days of 1942–43 Major Whittaker, as he was then, found himself stationed in the vicinity of the University of Cairo. Stimulated by contact with the active mathematicians of that University, he started to deliver a course of lectures on the subject of his peace-time research. The course was cut short when he was transferred to another theatre of war. The lectures delivered were edited by Prof. Mursi, of the Fouad I University, Cairo, and published in pamphlet form by the Faculty of Science of that University. They deal with simple and other basic series, Cannon series, series effective on a circle, representation near a point, algebraic theory (using matrices), uniqueness, convergence, integral functions, and successive derivatives.

Resistance Welders and the Electricity Supply Industry

In a recently published paper on this subject (*J. Inst. Elec. Eng.*, 92, Part 2, No. 30; Dec. 1945) the author, R. B. Giles, is primarily concerned with the effect of the A.C. resistance welder upon the networks of public supply authorities and the problem of securing an equitable revenue for the service rendered to the user. To that end, the electrical characteristics of the welding machine are detailed, together with some particulars of experience and consumption of energy in the metal trades, both of Great Britain and of the United States. There is a brief reference to the D.C. capacitance-storage welder, which is of comparatively recent development, and some details of the energy used by this type of machine are given. Proposals are made for a standard specification for the use of welder manufacturers and for the more satisfactory guidance of the supply authority and the user. The possibilities of a special tariff for welder consumers are also discussed.

Society for Endocrinology

Contributors to the *Journal of Endocrinology* have recently taken the initiative in the formation of a Society for Endocrinology, the object of which is to promote the advance of endocrinology by observational, experimental and clinical studies. The Society was founded at an inaugural meeting held at Guy's Hospital, London, on April 26, when the following elections were made: *Hon. Secretary*, Dr. S. J. Folley; *Hon. Treasurer*, Dr. C. W. Emmens; *Hon. Editor* of the Society's Proceedings, Prof. S. Zuckerman; *Members of Committee*, Dr. P. M. F. Bishop, Dr. A. S. Parkes, Mr. P. C. Williams, Prof. F. G. Young. In addition to ordinary meetings at which original scientific communications will be presented, the Society hopes to organise from time to time symposia on selected topics in the field of endocrinology. The address of the Hon. Secretary is: c/o The National Institute for Research in Dairying, Shinfield, near Reading.

Society for the Study of Evolution

A Society for the Study of Evolution was formed on March 30, 1946, on the occasion of the meeting of the American Association for the Advancement of Science at St. Louis. The object of the Society is the promotion of the study of organic evolution and the integration of the various fields of biology, such as taxonomy, palæontology, genetics, that are interested in evolution. The elected officers are: *President:* Dr. George G. Simpson; *Vice-Presidents:* Prof. Ernest B. Babcock, Prof. A. E. Emerson, and Prof. J. T. Patterson; *Secretary:* Dr. Ernst Mayr; *Treasurer:* Mr. K. P. Schmidt; *Council:* Prof. R. Chaney, Prof. Th. Dobzhansky, Prof. E. R. Dunn, Prof. G. Jepsen, Prof. H. J. Muller, and Prof. Sewall Wright. Communications should be addressed to the secretary, Dr. Ernst Mayr, American Museum of Natural History, Central Park West at 79th Street, New York 24, New York.

Society of Glass Technology

According to the report for 1945 of the Council of the Society of Glass Technology, presented at the annual general meeting held at Sheffield on April 25, there are now an Indian Section and five local sections, in addition to the parent body. The total membership exceeds one thousand, distributed through thirty-five countries. Prof. H. Moore retired from the presidency, after holding office for two years, and was succeeded by Mr. Geoffrey I. C. Marchand, director of the Glass Manufacturers' Federation. Prof. W. E. S. Turner, honorary general secretary, will retire on May 31, and Dr. J. H. Partridge, of the Research Laboratories

of the General Electric Co., Ltd., Wembley, will succeed him. Mr. F. G. Orme, general treasurer, will be succeeded by Mr. A. E. Hill. Prof. Turner, founder of the Society, who has exercised a profound influence on its development for a period of thirty years, will continue to act as editor of its journal.

Summer School in X-ray Crystallography 1946

By the courtesy of Prof. C. E. Tilley and of Sir Lawrence Bragg, a Summer School in X-ray Crystallography will be held for the fourth consecutive year in the Department of Mineralogy and Petrology, and in the Cavendish Laboratory, Cambridge. The School is conceived as a means of providing an introduction to the fundamental theory, methods, and techniques of X-ray diffraction, so that those whose researches, whether in the universities or in industry, lie in the field of physics, chemistry, metallurgy, mineralogy, or biology may be able to recognize in their own work the types of problem to which these methods may with advantage be applied. The greater part of the course will be devoted to practical work on the interpretation of the various types of X-ray photograph. For the last two days, however, alternative lectures and demonstrations will be offered in A and B sections. The A section will include further steps, theoretical and practical, in the study of crystal structures, while in the B section some applications of the earlier work of the course to metallurgical problems will be studied. The School will be held from Monday, September 2 to Friday, September 13 inclusive. A detailed syllabus and form of application for admission can be obtained from Mr. G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge, to whom the completed application form should be returned not later than July 1.

Exhibition of Chemical Research

An exhibition of chemical research, organised by Imperial Chemical Industries, Ltd., is to be held at the Tea Centre, Lower Regent Street, London, S.W.1, during June 5–28. The exhibition is designed to show some of the major achievements of chemical research in Britain during the War, and to demonstrate their even greater importance in peace-time. The section "The Chemist versus Disease" will show the part played by chemical research in combating disease and improving sanitation, conditions of a century ago being contrasted with those of to-day. Particular emphasis is laid on the sulpha drugs, penicillin and 'Paludrine', and their significance in chemotherapy is explained. "The Chemist and Your Food" will outline the part played by the chemical industry in modern agriculture. Though synthetic fertilizers will be shown, this section will be mainly concerned with the evolution of chemical methods for combating moulds, bacteria and weeds. The discovery, development and use of the new selective weed-killer, 'Methoxone', will be illustrated with models, diagrams and photographs. Chemical warfare against predatory and disease-bearing insects will have a section to itself. The insecticide 'Gammexane' will be illustrated by specimens and molecular models of the four isomers of benzene hexachloride. The section on "The Chemist and Plastics" will centre around 'Perspex' and polythene. The history of 'Perspex' will be demonstrated, and a molecular model will illustrate the polymerization of methyl methacrylate. The technical interest of polythene lies in the fact that its production, by the polymerization of ethylene, involves pressures higher than those used in any other industrial processes. Polythene is also unique in being the simplest synthetic thermoplastic, composed of long methylene chains of 1,000 units or more. Exhibits will show its electrical properties, its use as a waterproof packing material for drugs, and for acid-proof containers, funnels and piping. The final section will be devoted to 'Ardil', the wool-like protein fibre made from ground nuts. Diagrams and models will demonstrate the breakdown of proteins into amino-acids, and the reassembly of these into proteins of a different nature. The process of the manufacture of 'Ardil' will be demonstrated, and fabrics will be shown in which it is combined with wool, cotton and rayon. The exhibition will be open daily from 10.30 a.m. to 8 p.m. (Sundays from 2 until 7 p.m.). A charge of 1*s.* will be made for admission, and all proceeds will be given to the Empire Fund for Cancer Research.

Announcements

The British Social Hygiene Council is organising a two-day conference to be held in Livingstone Hall on June 6 and 7. The aim of the conference is to provide a platform in which men of science and religion can meet in a common search for truth. Among the speakers will be: Sir Ernest Barker, Dr. K. E. Barlow, Mr. R. F. Harrod, Miss E. C. Knight Bruce, Rev. P. J. Lamb, Father J. Leycester King, the Dean of St. Paul's, Lord Moran, Dr. Basil Yeaxlee, Prof. A. V. Hill. Further information and tickets (price 10*s.*) may be obtained from the British Social Hygiene Council, Tavistock House North, Tavistock Square, London, W.C.1.

A conference on "Certain Aspects of the Action of Radiation on Living Cells", arranged by the British Institute of Radiology, will be held at the Reid-Knox Hall, 32 Welbeck Street, London, W.1, during May 13–14. The four sessions will cover the physics of irradiation and effects on viruses, action on aqueous solutions, action on chromosomes and effects on germ cells with special reference to man.

The Illuminating Engineering Society is holding a convention during May 14–16. Meetings will be held at the Institution of Electrical Engineers for the presentation of papers on lighting during the War, problems of visibility, lighting of airports, daylight in relation to town planning, and fluorescent lighting practice. An exhibition of war-time applications of lighting and of post-war developments is being arranged at the Lighting Service Bureau, 2 Savoy Hill, Victoria Embankment, London, W.C.2, during May 14–16.

The trustees of the Busk Studentship in Aeronautics hope to make an appointment during June next. The Studentship is of the value of about £165, tenable for one year from October 1, and is open to a British subject of British descent who has not attained the age of twenty-five years on October 1. The object of the Studentship is to enable the holder to engage in research, or preparation for research, in aeronautics of the kind in which Edward Busk was specially interested; namely, those involving experimental as well as mathematical investigation. Application forms, to be returned by June 1, can be obtained from Sir Melvill Jones, Engineering Laboratory, Cambridge.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Persistent Solar Rotation Period of 26·875 Days and Solar-Diurnal Variation in Terrestrial Magnetism

FROM an examination of the solar-diurnal variation in the horizontal force of the terrestrial magnetic field at Godhavn, Greenland, it has been established that the amplitude of the daily variation due to disturbance, S_D, varies in a regular way over a period of 26·875 days, so that the mean amplitude of S_D on the ninth day of the period is four times as great as that on the nineteenth day. The investigation was made in the following way: the days in the period (seven sequences of 27 days followed by one of 26 days) were numbered 0–26, and the material used consisted of 185 sequences of 26·875 days covering the epoch July 1, 1926–September 11, 1940 (eight periods in 1931 in which the material had not yet been fully prepared being omitted). Only the sequences for the summer months, May–August, were used at first. The daily variation due to disturbance, $S_D = S - S_q$, was determined for the 1st day of the period (mean of the 0th, the 1st and the 2nd day), the 4th day (mean of 3rd, 4th, 5th day), 7th, 10th, 13th, 16th, 19th, 21st, 25th day for the total epoch (66 series). S_D was analysed harmonically, the non-cyclic variation being eliminated at first, and the two first Fourier coefficients were

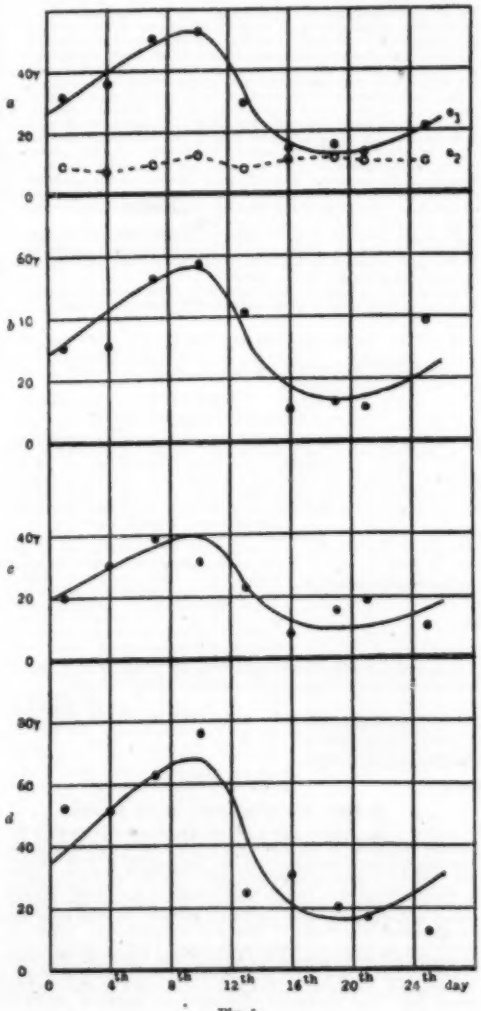

Fig. 1.

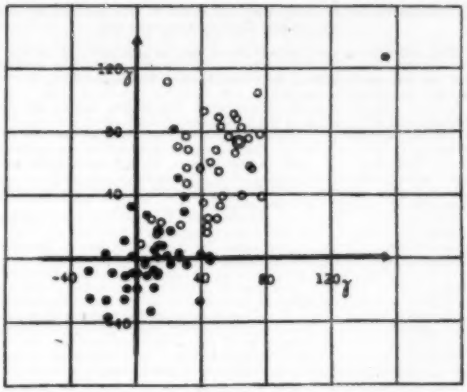

Fig. 2.

determined (the 24- and the 12-hour term). Fig. 1 *a* gives the amplitudes c_1 and c_2 as functions of the number of the day. Next the material was divided in three groups: the disturbed summers 1926–31, the quiet summers 1932–36, and the disturbed summers 1937–40. The resulting values for c_1 are given in Fig. 1, *b*, *c* and *d*, where the marked points represent the observed values and the full curve is the curve from Fig. 1 *a* multiplied by a convenient factor. Figs. 1 *b*–*d* confirm that the period is persistent throughout the fifteen summers. Comparison of 1 *b*, 1 *c* and 1 *d* makes it probable that the length of the period has an error of ± 0·025 day.

The variation of c_1 practically vanishes in winter and is not met with at Lovoe, near Stockholm, a little south of the auroral zone, the data for which have been examined for the summers 1937–40. A rough examination of H at Huancayo, Peru, during 1932–34 gave a negative result too. The vanishing of the effect in winter shows that a sunlit atmosphere is necessary, but the negative result at Lovoe seems to indicate that the effect is not due to a variation in the emission of ultra-violet light from the sun, but that charged particles from the sun are also a necessary factor. It should be pointed out that the big decrease of H that manifests itself as high values of S_D on disturbed days takes place at local noon at Godhavn, just at the hour when the magnetic daily disturbance is at its maximum. It therefore looks as if the high S_D's are due to a co-operative effect between the sunlit ionized atmosphere and the maximum stream of charged corpuscles from the sun. At Lovoe, however, the maximum daily magnetic disturbance takes place at local midnight and the corpuscles hit a dark atmosphere. It seems, therefore, most probable that the effect found at Godhavn is restricted to places north of the auroral zone, where the maximum magnetic disturbance occurs at noon. Unfortunately, the magnetic registrations from such observatories during the second polar-year 1932–33 are of too short duration to serve as a control of the effect found.

The international character-figure, C, does not show the period found; but by selecting days of different values of C, it has been shown that the amplitude of S_D increases with increasing values of C in such a way that this increase is much more marked on the 9th day than on the 19th, so that the mean amplitude c_1 for days with $C \geqslant 1{\cdot}0$ is three times as great for the 9th day in the period as for the 19th. This result may be interpreted in three ways: (1) a periodic variation of the ionization by ultra-violet light (unlikely, as this should be a world-wide phenomenon); (2) a periodic variation of the intensity of the stream of charged corpuscles; (3) a periodic variation in the deflexion of charged particles emitted from the sun.

The persistence of a fixed period of rotation of the sun covering fifteen years seems to indicate that the corpuscles giving rise to the c_1-variation are controlled from an inner layer in the sun with a fixed speed of rotation.

In order to ascertain whether the regular variation of c_1 is restricted to means for many days (in Fig. 1 a mean of 198 days) a harmonic dial has been worked out for the 'single' days 10 and 21 (using for every day a mean of three days, as above). Fig. 2 shows the harmonic dial for the 42 single days in the disturbed summers 1926–31 and 1937–40 (the sine-coefficients being abscissæ, the cosine-coefficients being ordinates). Fig. 2 indicates that S_D for almost every day in the 10th day group is that of a disturbed day (S_D for the five international disturbed days is marked as a double circle), whereas for almost every day in the 21st day group it is that of a quiet day (corresponding to point 0·0).

Let a_{10} and a_{21} be the means of the sine-terms in Fig. 2 for the 10th day group and the 21st day group respectively, and b_{10} and b_{21} the corresponding means of the cosine-terms; assuming next that the deviation of a point in a group from the group-mean is accidental, then we can compute the mean error of a_{10}, a_{21}, b_{10} and b_{21}. We find: $a_{10} - a_{21} = 29{\cdot}4 \pm 5{\cdot}6\,\gamma$ and $b_{10} - b_{21} = 46{\cdot}7 \pm 6{\cdot}7\,\gamma$, which is further evidence of the reality of the period found.

The regularity of the curve in Fig. 1 *a* seems to indicate that charged corpuscles emitted from the sun form a broader and more homogeneous stream than previously assumed. This is in good accordance with the fact often observed in the arctic that magnetic days occur at the same hour of the night in sequences of several days.

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Quantitative Analysis by the Variation of the Specific Activity of an Added Radioactive Isotope

In a mixture of ions, one of them can be estimated by adding to the solution its radioactive isotope. The specific activity is modified, and one can deduce from that modification the concentration of the inactive ion initially present.

Various researches have already been undertaken in this direction. Delépine[1] in 1925 indicated the possibility of estimating the quantities of optical isomers in a given sample. Later, Hevesy and Hobbie[2] estimated traces of lead in rocks using its natural isotope radium D as an indicator. In 1939 Schoenheimer, Ratner and Rittenberg[3], and Ussing[4], effected the estimation of organic compounds with the aid of heavy isotopes, and Rittenberg and Forster[5] gave detailed examples of analysis of amino-acids.

The artificial radioactive isotopes which had not yet been employed in analysis naturally afforded great interest. In this first account, we review briefly the results obtained in the estimation of potassium effected in the presence of lithium and sodium.

To the solution containing these three elements a measured quantity of ions (K^* + K), having a known activity, was added. From the new mixture the potassium is precipitated as an insoluble salt such as the perchlorate. One part of it is isolated and weighed, and from the new activity the quantity of inactive ions initially present in the solution is deduced. The advantage of this method is obvious: the precipitation does not need to be quantitative, it is sufficient to isolate one part of the salt in a pure state to find out its specific activity.

Our determination of quantities of K from 1–0·1 gm. (in potassium chloride) mixed with 13·6 gm. of salts (sodium and lithium nitrates) gave results accurate to within 1 per cent. One can also consider the estimation of complex organic compounds such as the alkyl halides, compounds of arsenic, sulphur, etc. The estimation of proteins containing phosphorus should be interesting, as the half-life of radiophosphorus is long (14 days). The analysis of iodine compounds of the thyroid gland will doubtless be feasible by this method, using iodine of half-life (8 days).

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[2] Hevesy and Hobbie, *Z. anal. Chem.*, **88**, 1 (1932).
[3] Schoenheimer, Ratner and Rittenberg, *J. Biol. Chem.*, **130**, 703 (1939).
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A New Flame Phenomenon

In the course of an examination during 1938 of the effect of the quality of coal gas upon the completeness of combustion in domestic gas appliances, a speedy method of determining total air requirement was developed.

Kind of gas	Gross C.V. B.Th.U. per cu. ft.	A.T.B. No. (*B* scale)	Sulphur grains per 100 cu. ft.	Products			Air/Gas ratio		
				CO_2 %	O_2 %	CO/CO_2 ratio	Observed	Calculated	
								(*a*)	(*b*)
Carburetted water gas	433	21·5	10	16·8	0·1	0·015	3·89	3·75	3·81
Vertical retort gas—*C*	451	33·0	24	11·8	0·5	0·0059	3·89	3·83	3·86
Vertical retort gas—*D*	449	31·3	20	12·3	0·3	0·0078	3·87	3·77	3·84
Town gas—*D*.	449	29·1	18	13·1	0·2	0·0070	3·82	3·78	3·84
Vertical retort gas—*E* (unstripped)	485	39·2	83	12·1	0·1	0·010	4·17	3·97	4·23

(*a*) Calculated from the gas analysis, assuming the unsaturated hydrocarbons to be C_2H_4.
(*b*) Calculated by the formula, developed by Mr. J. W. Wood

$$\text{C.V.} \times \frac{1{\cdot}055}{100} - 0{\cdot}97 + (0{\cdot}97 \times \%\ \text{inerts}) - \frac{\%\ \text{oxygen}}{21}.$$

Previously this figure had normally been obtained by one of two methods: (*a*) calculation from the composition of the gas; (*b*) direct combustion by explosion or catalytic oxidation. In the method to be described, the air required per cubic foot of gas for complete combustion can be determined directly by measurement of rates of flow of air and gas. The flame itself provides a satisfactory criterion when the correct ratio is attained.

The apparatus is essentially a simple tube burner to which a mixture of air and gas in controlled proportions is delivered. The burner is set in an enclosure of which the exit is made sufficiently small to maintain a slight excess of pressure over the external atmosphere and prevent back diffusion of air to the flame. The flame is, therefore, surrounded by its own products of combustion. The enclosure is formed by a tall glass cylinder sealed to a solid base supporting the burner. At the top of the cylinder there is a loosely fitting lid with two small holes.

With excess air the flame, as seen in a darkened room, has a lilac-coloured inner cone surmounted by an envelope of paler lilac shade. At the top of the outer envelope the colour changes to a reddish hue. When the ratio of air to gas is slowly reduced there comes a point where the outer envelope suddenly increases about three-fold in height. Further slight reduction in the air/gas ratio causes the height of the outer envelope to decrease again, and this is accompanied by the appearance of a small violet-blue flame at the base of the main flame, there being a dark space between the two flames. With further progressive reduction in the air/gas ratio the violet-blue flame gradually increases in length, while the intensity of the colour increases to a maximum and then decreases. Finally, the whole flame is suddenly extinguished at an air/gas ratio well below that required for complete combustion of the gas.

The name 'calyx'—owing to its resemblance to the calyx of a flower—has been given to the violet-blue flame. The violet-blue colour appears to be the more intense the higher the sulphur content of the gas. In collaboration with Dr. E. C. W. Smith, a spectrogram of the calyx flame obtained with town gas has been taken and this shows very clearly the characteristic S_2 lines between 3369 A. and 4444 A. No other lines are visible. Dr. G. Whittingham[1] has observed the S_2 lines in a spectrogram of a coal gas flame to which sulphur dioxide has been added.

Consideration of the equilibria existing in the flame produced by a coal gas/air mixture containing slightly less than the theoretical amount of air suggests that the sulphur may arise from the reaction:

$$2\,SO \rightleftarrows SO_2 + \tfrac{1}{2}S_2.$$

At the temperature existing in the flame, this system is composed predominantly of SO, and a considerable fall in temperature is necessary for the formation of S_2 in sufficient concentration to give a visible flame. This may explain the dark space between the main flame and the calyx.

It is probable that the violet-blue zone that can be seen as a thin line beneath a kettle when an aerated coal gas flame impinges upon it is essentially the same phenomenon. The local conditions under which it is formed are similar to those necessary for the formation of a strongly developed calyx, namely, a deficiency of air and a relatively low temperature.

Experiments were made with hydrogen and air, in both of which the sulphur concentration was known to be less than 0·5 parts in two million parts by weight; and the violet-blue flame was detectable although it was more diffuse than the well-defined calyx flames obtained with coal gas and air. Another striking difference is that with hydrogen the violet-blue flame appears to be in a state of considerable turbulence not observed in the case of the other gases.

Measurements were made with various coal gases, for the detailed analyses of which we are indebted to the Gas Research Board. Gas- and air-rates were measured by means of calibrated flow meters, both gas and air being saturated with water vapour at room temperature. Starting with the mixture on the air-rich side, the air-rate was gradually decreased, and at the point of appearance of the calyx a sample of the products of combustion was taken for analysis. The existence of the calyx is sensitive to changes of the proportion of air of less than 1 per cent of the total air requirement. The results of the tests are given in the table appended.

From the point of view of appliance design, the CO/CO_2 ratios are of direct significance. These are all within the range normally regarded in the gas industry as indicating satisfactory combustion, and the corresponding air/gas ratios therefore give the minimum proportion of air required to burn the gas completely. The air/gas ratios calculated from analytical data approximate to the observed values.

Observations with gases ranging from 347 to 522 B.Th.U. per cu. ft. indicate that the method can be applied to any town gas.

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[1] *Nature*, **156**, 207 (1945).

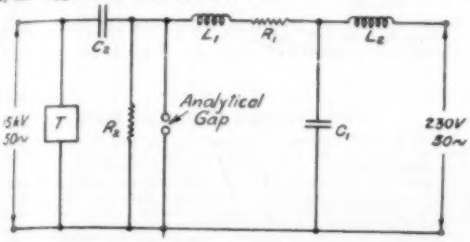
A New Spectrographic Spark Source

About a year and a half ago, our attention was directed to the relative instability of the condensed spark sources generally in use for quantitative spectrographic analysis. Consequently, work was carried out with the object of stabilizing the electrical excitation conditions in the analytical gap. The investigation led us to consider two general types of excitation circuits, namely, the high-voltage high-power circuit and the low-voltage controlled A.C. arc. In both these circuits the discharge is initiated by means of a synchronized trigger-circuit employing enclosed auxiliary spark gaps of the 'Trigatron' type (a three-electrode gap enclosed in a high-pressure argon–oxygen mixture).

The control of the main discharge by means of an auxiliary gap was originally suggested by Feussner[1], who used a synchronous rotary spark gap. The attainment of satisfactory operation of the inter-

rupter has, since that time, engaged the attention of a number of workers, and the consensus of opinion is that the interrupter gap should be irradiated from a source of ultra-violet light. This method has been recommended by Simpson[1], Fowler and Wolfe[2] and others. The use of 'Trigatrons' and an electronic synchronizing circuit (patent applied for) obviates the necessity of providing an external source of ultra-violet radiation and also eliminates the difficulties caused by the hunting of synchronous motors. The characteristics of the discharge in the 'Trigatron' gap itself are extremely stable.

The first type of circuit, the high-voltage spark source, consists of a conventional condensed spark circuit using a 4 kVA. transformer operating at 10 kV. R.M.S. charging a condenser of capacitance 0·01–0·04 μF. The discharge through the analytical gap is controlled by the trigger circuit mentioned above.



The circuit of the controlled A.C. arc is shown in the diagram. The discharge is triggered by means of a high-voltage impulse generated by the trigger circuit T in conjunction with C_2 and R_2. The energy for the main discharge is provided by the condenser C_1, and the discharge characteristics are governed by L_1 and R_1. The condenser C_1 is charged from the 230 V. supply and the circuit L_2C_1 is tuned to a frequency of 50 or 100 c./s., thus allowing the voltage on C_1 considerably to exceed that of the supply.

Our investigations have led us to devote our attention to the development of the controlled arc circuit, which appears to allow the attainment of higher accuracies than have been possible with the high-voltage source. A detailed account of the circuit will be published at a later date.

We wish to express our gratitude to Dr. J. D. Craggs and Dr. J. M. Meek for their valuable assistance in the early stages of this work.

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[2] Simpson, S. F., *J. Opt. Soc. Amer.*, **35**, 46 (1945).
[3] Fowler, R. G., and Wolfe, R. A., *J. Opt. Soc. Amer.*, **35**, 170 (1945).

Raman Effect in Rock-Salt

Born and Bradburn[1] have deduced the nature of the Raman spectrum of rock-salt to be expected on the basis of the Born lattice dynamics. They claim to have explained satisfactorily the observed features of the rock-salt spectrum reported by Fermi and Rasetti[2]. I believe that their theoretical results cannot be reconciled with the observed facts[3].

The main contention of Born and Bradburn is that in the observed spectrum the so-called Raman lines are only "small peaks on a strong background", a feature which is characteristic of the spectrum deduced from the Born dynamics. This description, which is mainly based on the microphotometer record reproduced by Fermi and Rasetti, is not justified. It is a familiar experience in microphotometry that even in the case of ordinary atomic spectra consisting of closely spaced sharp lines, microphotometric records of heavily exposed spectrograms exhibit the lines only as small kinks on a strong background. In order to gauge correctly the nature of the spectrum in such cases, it is necessary to take weakly or moderately exposed spectrograms and examine them by microphotometer. The photograph taken by Fermi and Rasetti and reproduced by Born and Bradburn itself bears testimony to the above statement. The intense Raman line with a frequency shift of 235 cm.$^{-1}$ appears only as a small peak on the Stokes side, whereas it is more prominently visible on the anti-Stokes side of the microphotometer record. It is also seen clearly as a line on the anti-Stokes side of the spectrogram and is so sharp that it may easily be mistaken for a mercury line.

The recorded Raman spectrum exhibits two prominent lines with frequency shifts 235 and 184 cm.$^{-1}$ which are recorded also in infra-red absorption roughly at the corresponding positions. These lines are a characteristic feature of the rock-salt spectrum. They are, however, completely absent from the spectrum deduced on the Born lattice dynamics.

Fermi and Rasetti remark in their paper that the Raman spectrum of rock-salt terminates abruptly at 360 cm.$^{-1}$. The observations made at Bangalore also definitely confirm this result, and show that the microphotometer record beyond this point arises from a continuum associated with the mercury lines at 2561·2 and 2563·9 A. The extension of the spectrum up to 500 cm.$^{-1}$ indicated by the Born lattice dynamics thus does not find experimental support.

The Born theoretical spectrum exhibits a couple of strong peaks in the region of low-frequency shifts. Investigations carried out at this Institute definitely show that there are no corresponding bands in the Raman spectrum. The band in this region appearing in the photograph taken by Fermi and Rasetti would appear to be a spurious one of instrumental origin.

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Asymmetrical Broadening with Multiple-Beam Interference Fringes

For the application of multiple-beam Fizeau's fringes[1] of equal thickness to the study of surface topography, it is necessary to know whether a displacement in the fringe pattern represents an increase or decrease in the interferometer gap. Previously this has been determined either by displacement of the reflecting surface[2], or if this is impossible, by examination with Tolansky's fringes of equal chromatic order[3].

This note describes a third method inherent in the Fizeau fringes and depending on their behaviour when the incident parallel beam is displaced from the normal by moving the pin-hole of the collimator off the axis. First, as may be seen from the basic formula $n\lambda = 2\mu t \cos\theta$, all fringes are displaced in the direction of t increasing, the displacement being proportional to the order of interference. Secondly, the fringes become broader, the peak intensity decreasing.

Thus if the source diameter is increased, each point forms its own set of fringes, and broadening towards the side of greater gap results. For high orders the first factor restricts θ to very small values, the second factor thus becoming negligible. The fringes then have a square-topped distribution characteristic of gaps of the order of a millimetre, even with very small pin-holes. For low orders, broadening is only observed with large sources, and because of the second factor the intensity of the wing decreases away from the normal position. In all cases the edge of the fringe towards the smaller t remains sharp and is located in the same place as for the fringes obtained with strict point-source collimation conditions. It may be noted that the broadening due to a slit source is independent of its radial inclination.

The photographs show multiple-beam monochromatic Fizeau fringes obtained with a point source (Fig. 1) and an extended source (Fig. 2), the fringes being formed in a thin air gap between silvered mica and a silvered optical flat[3]. With a point source, parallel beam and normal incidence, the fringes are very sharp. Removal of the pin-hole produces the asymmetrical fringes which can be used to interpret the contour directions absolutely in terms of 'hills' and 'valleys', for the wing of a fringe is always on the side of the greater air gap. The crystal surface illustrated represents a 'col' with 'hills' to the north-east and south-west and 'valleys' to the north and south-east.

In some cases measurements can be made on the sharp edges of the broadened fringes with nearly the same precision as on the collimated sharp fringes. The gain in intensity is so great (up to a 100 times) that the loss of accuracy may possibly be tolerated, particularly if high magnifications are needed. Variations of intensity within the wing of the broadened fringe can also clearly delineate details of surface relief.

Broadening similar to the above has also been observed on Tolansky's fringes of equal chromatic order, the wing in this case always appearing on the blue side of the fringe. Since with this type of interference there is never any doubt about which are hills and valleys, the application of such an asymmetrical broadening has not the same value as in the case of Fizeau fringes. The phenomenon in both fringe types, however, must always be present to some extent with pin-holes of practical size, diffracted and scattered light adding to the effect. For these reasons multiple-beam fringes of the Fizeau or Tolansky type often exhibit a slight wing on one side instead of being perfectly sharp, if critical illumination conditions are not obeyed.

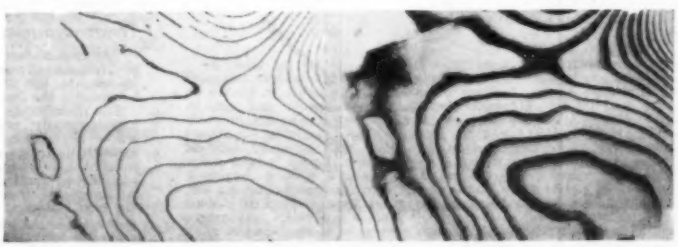

Fig. 1.

Fig. 2.

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[1] Tolansky, *Proc. Roy. Soc.*, A, **184**, 41 (1945).
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Saddle-Point Methods in the Cascade Theory

ACCORDING to Landau and Rumer[1] and others, the number of electrons of energy greater than E produced by one fast electron of energy E_0 under a layer t cascade units thick is given by the formula, neglecting the collision loss and Compton effect:

$$N = \frac{1}{2\pi i}\int_{s_0-i\infty}^{s_0+i\infty} \frac{1}{s-1}\left(\frac{E_0}{E}\right)^{s-1} \left\{\frac{D-\lambda}{\mu-\lambda}e^{-\lambda t} + \frac{\mu-D}{\mu-\lambda}e^{-\mu t}\right\} ds. \quad (1)$$

The integral is usually split into two terms containing the two exponentials, the first is evaluated by the saddle-point method and the second is neglected.

In the following we confirm in a simple way that neglecting the second exponential does not lead to an appreciable error provided $t \gg 1$; at the same time we show that the saddle-point method can still be applied for small values of t.

In fact, one can write the integrand of (1)

$$\frac{1}{s-1}\left(\frac{E_0}{E}\right)^{s-1}\left\{\frac{D-\lambda}{\mu-\lambda}e^{-\lambda t} + \frac{\mu-D}{\mu-\lambda}e^{-\mu t}\right\} = e^{\psi(E_0/E,\, s,\, t)}; \quad . \quad (2)$$

and determine the saddle point by

$$\frac{\partial\psi}{\partial s} = 0 \qquad \text{for } s = s_0. \quad . \quad . \quad (3)$$

One obtains for the integral in the normal way

$$N = \left(\frac{e^{\psi}}{\sqrt{2\pi\,\dfrac{\partial^2\psi}{\partial s^2}}}\right)_{s=s_0} \quad . \quad . \quad . \quad (4)$$

It is immediately clear that the term containing $e^{-\mu t}$ can be neglected in (3) and (4) without affecting N appreciably, provided

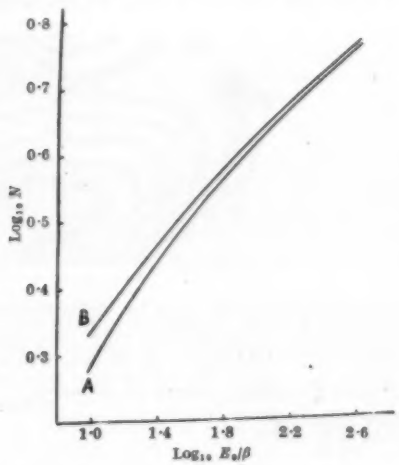
$$\mu t \gg \lambda t \qquad \text{for } s = s_0. \quad . \quad . \quad . \quad (5)$$

Thus (3) and (4) reduce to the expressions which are obtained when neglecting the $e^{-\mu t}$ term to begin with.

We note that (3) and (4) can be used even if t is small. To take the extreme case for $t = 0$, we obtain

$$\frac{e^{\psi}}{\sqrt{2\pi\,\dfrac{\partial^2\psi}{\partial s^2}}} = \frac{e}{\sqrt{2\pi}} = 1{\cdot}08; \quad . \quad . \quad (6)$$

whereas the exact value is $N_{t=0} = 1$. Thus the error due to the saddle-point method is only 8 per cent. The exp. $-\mu t$ makes an important contribution to (4).



E_0, ENERGY OF PRIMARY PARTICLE; β, CRITICAL ENERGY OF THE LAYER.

Actually we can apply this method to the expression given by Bhabha and Charkrabarty[2], including the collision loss. We have calculated $N(t = 1)$, using the first term of Bhabha and Charkrabarty series in powers of β/E_0. The result is given in the accompanying graph, where curve B is the result obtained by neglecting the exp. $-\mu t$ term, and curve A the result by using the exact expression. The energy of the primary particle ranges from 10 β to 400 β and the corresponding difference between the two curves from 15 to 2 per cent.

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[1] Landau and Rumer, *Proc. Roy. Soc.*, A, **166**, 213 (1938). Serber, *Phys. Rev.*, **54**, 317 (1938).
[2] Bhabha and Charkrabarty, *Proc. Roy. Soc.*, A, **186**, 267 (1943).

Elastic Constants of Isotropic Media

USING ultrasonic waves of continuously varying frequency, it was recently observed[1] in this laboratory that characteristic thickness shear modes could be transmitted through crystal plates and communicated to liquids in the form of consequential longitudinal strains. Further work on these lines has revealed that such modes can be similarly transmitted through isotropic media. This offers a new method of obtaining the entire frequency spectrum of a given plate, and therefore its elastic constants, even when it is available only as a small fragment. Using a tourmaline wedge with a frequency range of 3–12 megacycles per second, plates of glass, steel and brass have been studied. Values of Young's modulus Y and the rigidity modulus n obtained are compared with the usual static results in the accompanying table.

Material	Smallest size used	Authors' results Y	Authors' results n	Static values Y	Static values n
Glass	7×7×0·93 mm.	4·80	1·76	4·60	1·80
Steel	8×8×0·64 ,,	21·71	8·40	19–20	7·7–8·3
Brass	10×6×0·58 ,,	9·77	3·50	9·7–10·2	3·5

The static values for glass were also determined for the same sample, and those for steel and brass have been taken from the literature. The unit is 10^{11} dynes per sq. cm. and the dimensions of the smallest plate used in each case are given although plates of larger size have also been worked upon.

The appearance in this case of shear modes as corresponding longitudinal waves in the adjoining liquid is presumably due to a coupling effect arising from the finite size of the plates. This view is supported by our observation that such modes gain in intensity and become prominent as the plate is made smaller.

A fuller report will be published elsewhere.

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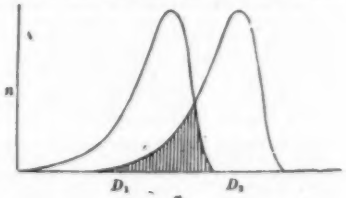
[1] Bhagavantam, S., and Bhimasenachar, J., *Proc. Ind. Acad. Sci.*, **20**, 298 (1944); *Nature*, **156**, 23 (1945).

Thermodynamics and the Logarithmic Temperature Scale

THE explanation of the reason for the existence of the Second Law of Thermodynamics and the meaning of entropy has always been inadequate, but the use of the logarithmic temperature scale[1] helps to simplify the fundamental concepts.

The distribution of gaseous molecular velocities has been studied experimentally[2], and is of the order shown in the accompanying figure where the distribution for two temperatures represented on the logarithmic scale as D_1[1] and D_2[2] are shown and which overlap. The nearer these two temperatures are to each other, the larger will be the number of molecules which are common to both temperatures. Although the common molecules are available for contribution to the heat energy at both temperatures, they will not be available for doing work. As the temperatures recede from each other more molecules are available for doing work.

A consideration of work and heat energy shows that work energy is defined by the use of a potential factor and a quantity factor,



whereas heat energy requires yet a third factor, such as entropy. The equation for the kinetic energy content of gaseous molecules was given by Clerk Maxwell and is of the order

$$E = \frac{Nm}{\sigma^3}\sqrt{\frac{1}{2\pi}}\int_0^\infty x^4 \exp.\ -x^2/2\sigma^2 dx,$$

where x is the molecular velocity, N the number of molecules, m the mass of one molecule and σ the standard, or root mean square (R.M.S.), deviation of the distribution. This equation integrates to $3/2\ Nm\sigma^2$ and gives the work energy of the molecules. The heat energy can be determined from temperature × mass of molecules × entropy. The mean temperature (or velocity) is obtained by the integration of

$$U = \frac{2}{\sigma^3}\sqrt{\frac{1}{2\pi}}\int_0^\infty x^3 \exp.\ -x^2/2\sigma^2 dx,$$

which gives $\frac{2\sqrt{2}}{\sqrt{\pi}}\sigma$. Hence the heat energy is $\frac{2\sqrt{2}}{\sqrt{\pi}}\sigma NmS$ and this is equal to the work energy, giving the entropy:

$$S = \frac{3\sqrt{\pi}}{4\sqrt{2}}\ \sigma \quad \text{or} \quad S = 0{\cdot}91\ \sigma.$$

Entropy thus varies with the standard deviation, that is, high entropy corresponds to a flat probability curve. The probability of a velocity lying between the values of x and $x + dx$ is proportional to exp. $-x^2/2\sigma^2$. This indicates that the logarithm of the probability is inversely proportional to the standard deviation, or entropy.

The kinetic energy equation given above indicates that the most convenient temperature (or velocity, or x)-scale associated with the standard deviation (or entropy) should be logarithmic compared with the energy content. Lewis and Gibson[3] showed the connexion between the specific heat of solids and the log T (or D)-scale; and the use of the percentage deviation, or 100 S/T, should form a measure of the accuracy of the values for entropy.

The question of the free energy release in a chemical reaction (omitting for the sake of simplicity, as before, all questions of constant pressure and constant column) can be summed up as follows. It has been shown experimentally that the driving force tending to make a reaction go in any one direction is the free energy, or work energy, which is released by the system. The release of heat energy, or the heat of the reaction $\triangle H$, is not a true guide. A method of determining the free energy change $\triangle G$ is by the use of the equation

$$\triangle G = \triangle H - T\triangle S,$$

where $\triangle S$ is the change in entropy.

If compounds A and B with entropies S_a and S_b are mixed, this is equivalent to adding two distribution curves; and since entropy is a function of the standard deviation, it is therefore permissible to add the entropies. At a given temperature when the reaction takes place the total change in entropy will be $(S_a + S_b) - (S_c + S_d)$. This is tantamount to saying that if the true measure of the potential of a chemical reaction is the free energy change (which for convenience is often expressed in heat units), then the final result from the heat change (heat of reaction) point of view can vary considerably from the work change value in either direction, depending upon whether the spread of the molecular velocities of the products is greater or less than those of the reacting molecules.

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London, W.C.1.
Feb. 2.

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Metastable Forms of Ice Produced by Super-cooled Water

In connexion with a recent letter[1] which describes these forms, it should be noted that the rule of successive states[2] would predict the preferential crystallization of the *least* stable solid state, in the absence of nuclei.

It may lead to confusion to refer to the ice separating at − 70° C. as a 'low-temperature form', since it frequently happens, owing to the operation of the above rule, that the metastable form which crystallizes most easily from melt or solution would in fact be the form which is stable at higher temperatures. For example, in the absence of nuclei, metastable β resorcinol (the 'high temperature form') separates from solution at low temperatures[2].

A consideration of the rule of successive states may explain the high symmetry of the crystal form of ice which separates at − 70° C. in the absence of nuclei, as the production of this form from super-cooled water might be expected to involve a smaller negative entropy of activation than less symmetrical crystal forms.

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Geochemistry of Magmatic Iron Ore

Considering the percentage of certain constituents in olivine and clinopyroxene separated from rocks of the Skaergaard intrusion, Greenland, L. R. Wager and R. L. Mitchell[1] determined, for these minerals, data which show a lower concentration of vanadium, chromium, nickel, magnesium (plus titanium and phosphorus in the case of vanadium ?, compare below), and a higher iron concentration the later the mineral was formed during the crystallization differentiation of the ancient Skaergaard magma. Comparing olivine and clinopyroxene containing similar relative concentrations of magnesium and iron, the former mineral is seen to be richer in chromium, cobalt and nickel than the latter, whereas the latter is seen to be richer in vanadium (plus titanium ?, compare below) than the former.

The late, ultra-basic rock (extremely poor in chromium) of Eastern Uppland, Sweden, earlier mentioned in *Nature*[2] is characterized by the following mafic minerals (from earliest to latest, concentrations given in parts per million):

	Olivine (Fe_2SiO_4 = 20%, Mg > Fe)	Clinopyroxene ($FeSiO_3$ = 30–35%, Mg > Fe)	Titano-magnetite ($Fe_2(Fe,Ti)O_4$ = 99%, very little Mg present)
Ti	< 100	< 100	70·000
V	50	300	7·000
Cr	6	5	< 0·5
Co	250	130	50
Ni	550	50	< 0·5

Comparing olivine and clinopyroxene, we find a distribution of the actual trace elements which is roughly similar to that displayed by the Skaergaard rocks (apart from chromium in olivine). Moreover, it is interesting to get established the existence of magmatic iron oxide ore lacking chromium plus nickel and, contemporaneously, showing quite a low cobalt content. It is also interesting to trace once again the affinity of titanium and vanadium to iron oxide ore separated from gabbroic magma.

The most remarkable tendency displayed by these data is, however, the decrease in chromium, cobalt and nickel contemporaneously with the decrease of magnesium and the increase of iron. In the Skaergaard rocks and minerals[1,2], as well as in several magmatic differentiates from Eastern Uppland[2], we have already seen that vanadium, chromium, nickel and, finally, cobalt, vanish together with magnesium. According to crystallo-chemical experience, vanadium may be saved from such disappearance by the presence of titanium or (and) phosphorus (compare the above-mentioned titano-magnetite). The remaining elements just considered show no similar 'loop-hole', however. Thus, their existence or non-existence in a rock belonging to a normal suite of magmatic differentiates depends upon the contemporaneous existence or absence of magnesium.

The higher the magnesium (plus titanium or/and phosphorus in the case of vanadium) content, the lower is the iron and the higher the vanadium, chromium, cobalt and nickel. This seems to be a very important rule concerning any series of normal magmatic differentiates. The following sequence of magmatic rocks from the skerries south-east of Stockholm illustrates it very well (all concentrations are given in parts per million):

	Quartz-diorite	Porphyritic gneiss-granite rich in microcline	Gneiss-granite	Pyroxene-bearing gneiss-granite
SiO_2	573,200	662,800	679,100	715,600
Mg	25,000	6,000	3,400	2,100
Fe	58,500	33,000	46,500	33,000
Ti	3,500	3,000	3,800	1,900
P	1,100	500	500	200
V	200	35	< 2·5	0
Cr	10	4	1·0	< 0·3
Co	40	1·0	< 0·5	0
Ni	25	2·0	1·0	< 0·2
Mg : Fe	0·43	0·18	0·073	0·064

In order to test the rule just mentioned, I separated magnetite from two typical pegmatites of eastern Sweden, each of which belongs to a suite of differentiated magmatic rocks showing *normal* contents of titanium, phosphorus, vanadium, chromium, cobalt and nickel when magnesium is present in, at least, moderate quantities. The results are as follows: (*a*) magnetite, south-east part of the Stockholm skerries, titanium, 8,000 p.p.m.; vanadium, 150 p.p.m.; chromium, weak trace; cobalt, weak trace, nickel, 0; (*b*) magnetite, central Roslagen, eastern Uppland, titanium, 10,000 p.p.m.; vanadium, 100 p.p.m.; chromium, weak trace; cobalt, weak trace; nickel, weak trace. In both species, most phosphorus was removed during the separation. Thus it is evident that vanadium follows titanium here.

As a consequence of a rule concerning normal magmatic differentiates as well as by means of a few examples, I have now established in the crust *the real existence of magmatic iron oxide ore very poor in, or lacking, chromium, cobalt and nickel* and separated from basic as well as acid magma portions.

Turning to magmatic iron sulphide ore, similar results have been found for nickel (no data on vanadium, chromium and cobalt are at present available). A great many analyses on Swedish pyrrhotite (pyrite in a few cases) associated with medium and late stages of the basic part of magmatic differentiation (iron greater than magnesium, pyroxene-gabbros especially) never fail to show a deficiency of nickel. On the contrary, a few samples of pyrrhotite separated from early gabbros (magnesium greater than iron, olivine-gabbros) display high nickel contents.

A concrete example of this is (*a*) pyrrhotite separated from early gabbro from Boden, northern Sweden, Ni : S = 60 : 1,000, olivine present; (*b*) pyrrhotite separated from late gabbro belonging to the same suite of rocks as the early gabbro mentioned in (*a*) Ni : S = 7 : 1,000, no olivine present.

An explanation of the trend considered in this letter is to be expected from the investigation of a number of systems of equilibrium of the type $FeSiO_3-MgSiO_3-NiSiO_3$.

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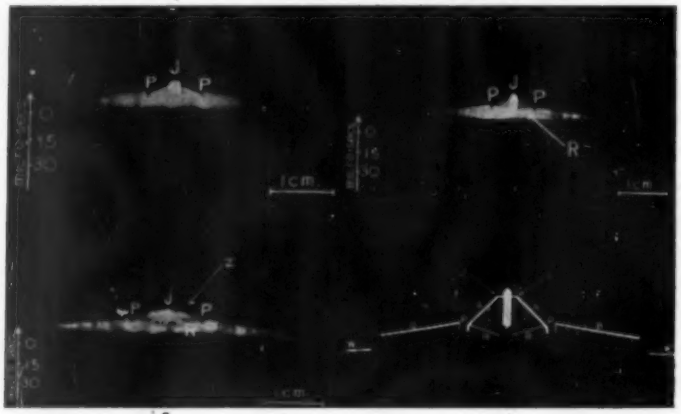
Initial Stages of the Explosion of Nitroglycerine

IT has been reported previously that when explosion is initiated in a thin confined layer of nitroglycerine by impact or by condenser spark, the characteristic pattern of pressure marks impressed on the confining surfaces indicates that the explosion proceeds through the layer in at least two successive stages[1,2]. This conclusion is supported by the disposition of the luminous effects observed when the explosion is initiated on a photographic plate or on a transparent anvil at the focus of a camera[3].

A rotating drum camera[3] has now been used to examine the initial stages of the explosion. The results obtained confirm and amplify the conclusions arrived at from the earlier experiments[1,2,4].

A thin layer of nitroglycerine was confined between a circular brass disk (3·5 cm. in diameter) and a transparent support. Initiation was effected by the passage of a condenser spark in a hole drilled at the centre of the disk, and the light from the explosion was photographed on a film carried by the rotating drum. Close to the drum and at right angles to the direction of rotation a narrow slit was interposed. Thus a trace was obtained from which the velocity of propagation of the explosion at any point along the line of the slit (that is, the diameter of the nitroglycerine layer) could be calculated.



1 and 2. ROTATING-DRUM CAMERA TRACES OF EXPLOSIONS IN VERY THIN LAYERS OF NITROGLYCERINE. ARROW INDICATES DIRECTION OF MOTION OF FILM.

3. TRACE OF EXPLOSION IN THICKER NITROGLYCERINE LAYER. 4. DIAGRAMMATIC REPRESENTATION OF EXPLOSION TRACE.

J, point of initiation; *Z*, initial process of very high velocity; *A*, propagation at *c.* 400 metres/sec.; *P*, dark space; *R*, 'retonation' wave; *B*, propagation at *c.* 2,000 metres/sec.; *W*, shock wave in atmosphere.

Figs. 1 and 2 are typical traces obtained with very thin layers (less than 0·01 mm.) of nitroglycerine. The explosion is initiated at *J* and propagates in both directions to *P* at approximately 400 (420 ± 15 per cent) metres/sec. At *P* the velocity abruptly increases to approximately 2,000 (1,800 ± *c.* 5 per cent) metres/sec. and a retrograde process *R* originates. *R* is seen more clearly in Fig. 2.

At *P* there is a dark space about 1 mm. wide. This shows that the 2,000 metres/sec. process begins at a point in the nitroglycerine layer ahead of the 400 metres/sec. explosion front. With suitable extension of the confined layer, the 2,000 metres/sec. process may be caused to propagate at stable velocity for at least 10 cm. This process presumably corresponds to the 'low velocity' detonation characteristic of nitroglycerine[5].

The initial stages of explosion in nitroglycerine under these conditions correspond quite closely, though on a much reduced scale, with the sequence of events characteristic of the setting up of detonation in gaseous explosions. In particular, the abrupt change in velocity, the appearance of a 'retonation wave' *R*, and the 'auto-ignition' of detonation ahead of the flame front are phenomena common to both systems[6].

When initiation is effected in a thicker layer (greater than 0·1 mm.) the 400 metres/sec. process is preceded by a very fast process (exceeding 5,000 metres/sec.), cf. Fig. 3. After a short distance of propagation (*JZ*) this is converted suddenly to the 400 metres/sec. process, after which the explosion proceeds exactly as in thinner layers. It is possible that this initial stage of the explosion corresponds to the 'high velocity' detonation[5]. Fig. 4 is an idealized diagram corresponding to an explosion trace obtained with a thick layer.

Similar results have been obtained with nitroglycol and methyl nitrate.

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Induced Dehydrochlorination of Substituted Ethanes

THE ease with which hydrogen chloride can be removed from simple aliphatic chloro-compounds by the action of alcoholic caustic alkali has been recognized for many years. It is also possible to split off hydrogen chloride from these compounds by contact catalysis, or simply by pyrolysis, and there are many patents covering these processes.

During the study of such a thermal dehydrochlorination of ethylene dichloride, it has been found that the velocity of the reaction is remarkably dependent on the presence of small amounts of oxygen and/or chlorine, and on the purity of the ethylene dichloride. The accompanying table illustrates results obtained during dynamic experiments in 11 mm. *I.D.* Pyrex tubes heated uniformly for a length of 60 cm., and with a flow-rate of 38 gm. of ethylene dichloride per hour. Ethylene chlorhydrin, which forms an azeotrope[1] with ethylene dichloride and which is normally present therein, inhibits the reaction, but can be removed by chemical treatment with, for example, sulphuric acid followed by fractionation.

In all cases the sole reaction products are vinyl chloride and hydrogen chloride with a trace of tarry matter. Packing the reactor with glass scrap to twice the original area caused a slight increase of reaction velocity (from 17 to 19 per cent conversion at 500°) for pure ethylene dichloride with no addition, but the oxygen- or chlorine-induced decomposition at 350° was almost completely inhibited under these conditions. The velocities of both induced reactions depended, for a constant contact time, on the reactor diameter increasing as this increased. Considerably smaller amounts of oxygen or chlorine than ½ per cent by weight had an appreciable influence on the rate of the decomposition, the effect of even 0·01 per cent by weight of chlorine, for example, being easily detected. The oxygen-induced reaction was particularly sensitive to the presence of inhibitors and was entirely suppressed by the addition of less than 0·1 per cent by weight of various aliphatic alcohols and hydrocarbons; for example, even 0·01 per cent of ethyl alcohol completely inhibited the reaction at 350°. Other halogens besides chlorine also induced the decomposition of ethylene dichloride: mole for mole, bromine was more effective than chlorine; but iodine, on the other hand, was almost without influence.

The effect of chlorine and oxygen in 'catalysing' the thermal decomposition of other chlorinated ethanes has also been studied. Remarkably enough, the effect of the added 'catalyst' depends very much on the structure of the chlorinated body. Thus, while the pyrolysis rates of pure 1,1,2-trichlor- and 1,1,2,2-tetrachlor-ethanes were profoundly affected, the velocities of decomposition of purified 1-chlor-, 1,1-dichlor-, 1,1,1,2-tetrachlor- and pentachlor-ethanes were almost uninfluenced. There is an obvious inverse correlation between these two groups and Markownikoff's rule.

Temp. in °C.	Percentage conversions				
	Fractionated $(CH_2Cl)_2$; no addition	Chemically purified $(CH_2Cl)_2$; no addition	Fractionated $(CH_2Cl)_2$; + ½% by wt. of oxygen	Chemically purified $(CH_2Cl)_2$; + ½% by wt. of oxygen	Chemically purified $(CH_2Cl)_2$; + ½% by wt. of chlorine
300	0	0	0	30	30
350	0	0	0	60	50
400	1	2	2	—	65
450	3	12	—	—	80

While the removal of hydrogen chloride from such molecules is clearly an endothermic process, there can be no doubt at all but that these induced pyrolyses are chain reactions. Although there is a superficial resemblance to the well-known iodine-catalysed decompositions of aliphatic ethers, ketones, etc., the two types of induced reaction must be quite different. The effectiveness of iodine in the ether and ketone reactions is to be related[1] to its facile dissociation to the atomic form; iodine is much superior, therefore, to chlorine or bromine, whereas, with the ethylene dichloride decomposition, such is not the case. Nevertheless, as with iodine-catalysed decompositions, the activation energies of the induced pyrolyses of ethylene dichloride are much less than that for the uncatalysed reaction. It is of interest that Sherman, Quimby and Sutherland[2] have already predicted, on the basis of calculated activation energies, that the decomposition of ethylene dichloride should be catalysed by halogens, but their method can offer no explanation as to the remarkable dependence of these induced reactions on molecular structure (see above). In any event, it is still not certain that these reactions are of the radical-chain type postulated by them, and a number of the experimental facts are in better accord with a 'hot-molecule' mechanism.

The investigation of the kinetics, mechanism and scope of these induced reactions is at present being undertaken. The industrial utilization of the facts presented here is covered by British Patents 573,532 and 573,559, but prior publication has been prevented by war-time secrecy restrictions.

I am greatly indebted to Dr. M. Mugdan, of the Distillers' Co., for his invaluable suggestions and advice, and to the directors of that Company for financial assistance and permission to publish this letter.

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Tetrapositive Nickel as Alkali Nickel Periodates

The formation of the black oxides of nickel as well as of the so-called nickelites suggests that nickel can occur in a state of valency higher than its normal value of two. Both ter- and quadri-valency for nickel have been assumed in these compounds, though they have seldom been obtained in a pure state with definite composition. Some apparently double molybdates of quadrivalent nickel with alkali and alkaline earth metals have been described and studied by Hall[1]. We have shown that these fine purple black crystalline compounds should be regarded as salts of complex heteropoly molybdic acid with tetrapositive nickel as the central atom. Measurement of the magnetic susceptibility of these complex nickelic molybdates in our Laboratory[2] has shown that they are all diamagnetic. This proves that the tetrapositive nickel atom in these serves as the centre of a *penetration* complex with octahedral d^2sp^3 hybrid bonds resembling the tripositive cobalt in cobaltic complexes. A consideration of the fact that tetrapositive nickel and tripositive cobalt possess the same number of electrons readily accounts for it.

We have now been able to prepare specimens of sodium and potassium nickel periodates with nickel in the tetrapositive state. These were prepared by oxidizing a mixture of nickel sulphate solution and the corresponding alkali periodate at the boiling temperature with sodium or potassium persulphate as the case may be. The substances form dark purple, almost black, insoluble fine crystals with metallic lustre and have a tendency to adhere to the walls of the beaker in the form of a bright mirror. Their composition is represented by the formula, $Na(K)NiIO_6.xH_2O$, apparently a mixed salt of orthoperiodic acid, H_5IO_6, the hydrogen atoms of which are replaced by one quadrivalent nickel and one alkali metal atom. Measurement of the magnetic susceptibility, however, shows that the substance should not be represented as an ionic compound by the simple formula as given above. A quadrivalent nickel ion in the normal state should give a high moment of 4·9 Bohr due to four unpaired electrons. The compounds, however, give rather a low moment of only 1·2 Bohr approximately. On the other hand, a diamagnetic susceptibility would, as in the case of the above-mentioned heteropoly nickelic molybdates, indicate the formation of hybrid d^2sp^3 bonds with an octahedral configuration of oxygen atoms around the tetrapositive nickel atom in the crystal. A quadrivalent nickel, like its higher homologues quadrivalent palladium and platinum, is likely to have a co-ordination number of six. The measured moment seems to favour the latter view, assuming a partial dissociation of the substance into KIO_4 and NiO_2 due to its temperature instability, which would account for the observed paramagnetic susceptibility giving a low moment value.

On this basis, the possible structure of these alkali nickel periodates in the crystalline state may be represented as follows. Each nickel, iodine or potassium atom is surrounded octahedrally by six oxygen atoms, and each oxygen is bound to one nickel, one iodine and one potassium atom showing a co-ordination number of three. The bonds between oxygen and nickel, as well as those between oxygen and iodine, are predominantly co-valent, due to strong polarizing power of the highly positive nickel (quadrivalent) and iodine (heptavalent) atoms, while those between potassium and oxygen are purely ionic. The compounds should, therefore, be represented by the formula, $Na(K)[Ni^{IV}(IO_4)]$.

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Superheating and 'Bumping' of Organic Liquids

The superheating and 'bumping' of some liquids is well known to organic chemists, but I wonder if the dangers of superheating are sufficiently widely realized. The following incident occurred recently.

Preparing butyl bromide by a usual method, I heated a mixture of *n*-butyl alcohol (90 gm.), hydrobromic acid (250 gm.) and sulphuric acid (110 gm.) under reflux in a 500 ml. flask on an electric hot-plate. By an oversight, I omitted the usual piece of porous pot. The temperature rose steadily until liquid was distilling back from the reflux condenser at the rate of about three drops a second, yet the surface of the liquid in the flask remained quiescent. Suspecting superheating and possible trouble, I switched off the hot-plate and let the flask and contents cool until the liquid was distilling back from the reflux at a rate of not more than one drop every ten seconds; then I lifted the condenser and dropped in a piece of porous pot. The result was astonishing, the contents of the flask being thrown with considerable violence against a wall three feet away. Fortunately, I escaped with nothing more serious than the loss of my preparation, some broken apparatus and an afternoon wasted in 'mopping up operations'; but the dangers of similar accidents with such corrosive mixtures in crowded school or university laboratories are too obvious to need stressing.

I believe that the use of the hot-plate in this instance helped to promote superheating; but I have found that even with the addition of sand or porous pot, this particular mixture is inclined to 'bump' badly during the early stages of the preparation and needs careful watching. Students will be well advised, if ever they have reason to suspect superheating, to turn off the heat at once and make sure that the liquid they have been heating has, in fact, cooled to below the normal boiling point before they add porous pot or proceed further with the experiment. This simple precaution seems obvious, but it receives scant mention in the usual text-books.

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Is Carotene a Provitamin A, or has it Biological Activity *per se*?

It is generally acknowledged that the carotenes are 'provitamins', but there is no clear definition of the term 'provitamin' in the literature; the general view seems to be that it is a compound which is not a vitamin itself but after minor changes is transformed into one. The organism may be incapable of carrying out this transformation (D-provitamins), or it may be able to do so (A-provitamins). The term 'provitamin A' was first used by Harris[1], while Moore[2,3] called carotene a precursor of vitamin A. The opinion of these and all subsequent authors seems to be based only upon Moore's experiments on storage of vitamin A. As in the rat the minimal doses necessary to cause storage are about ten times those giving optimal biological effect[4,5], the deposition and the biological action take place at widely separated dose-levels. Further, the former takes place in the liver[4,5,6], while the latter takes place all over the organism (surface epithelium, nerve cells, retina) where it cannot be followed by chemical analyses. Thus these two processes are not identical, and one cannot conclude that the carotenes do not possess biological A-action *per se* because they are stored in the form of vitamin A.

Moore[7] writes: "Both carotin and the classical 'vitamin' may independently possess the same physiological action—" but this possibility is not mentioned in his later papers. Palmer[8] writes of certain A-active artificial compounds: "It is not known whether this biological activity is due to the fact that they are changed to the classical vitamin A in the body or possess physiological activity *per se*", but that the same can be said of the carotenes themselves is not mentioned.

The optimal requirement for vitamin A in mammals is 15–25 I.U. or 5–8 γ per kgm. a day and for β-carotene 30–50 I.U., or 18–30 γ[4]. The amount of vitamin A (in γ) stored as a percentage of the A-active substance (in γ) given is 15–25 for vitamin A and 1·2–3·8 for β-carotene in the rat[4,6]. In the hen the requirement is 100–200 I.U. or 33–66 γ per kgm. a day for vitamin A and 100–200 I.U. or 75–150 γ for β-carotene[9,10]. So the requirement of β-carotene in the hen is twice that of vitamin A and in mammals four times that of vitamin A. As the hen's requirement is about ten times that of a mammal, it suggests that small birds which seem to have a vitamin A requirement per kgm. many times greater than the hen[11,12] might show yet greater differences and be experimental subjects worth attention.

α- and γ-carotene[13], cryptoxanthin[14] and β-oxycarotene[15] are about half as active as β-carotene, which is in good agreement with the fact that each molecule of these substances can form one molecule of vitamin A, while β-carotene can form two. From the data in the literature[14,17,14], it is possible to calculate the storage percentage of these carotenoids as 4–8 per cent for β-carotene and a third to a half of this for the others with the exception of β-oxycarotene, which gives 0·1 per cent[14]. In hens the activity and storage of cryptoxanthin is known from experiments with yellow corn[9,16]; 90 γ of β-carotene showed the same biological action as 36 γ cryptoxanthin plus 18 γ of β-carotene, and 2·2 mgm. cryptoxanthin plus β-carotene (with two thirds cryptoxanthin) caused the same storage as 12 mgm. β-carotene. So the activity of cryptoxanthin must be about twice that of β-carotene in the hen—compare 90 γ and 36 + 18 γ—and the storage capacity for cryptoxanthin is even higher than that for β-carotene. As in the hen, the biological activity of vitamin A per γ is about twice that of β-carotene, the activity of vitamin A and cryptoxanthin must be of the same order of magnitude. As cryptoxanthin can produce, at the most, half its weight of vitamin A, this means that it must possess vitamin A activity *per se* in the hen.

This points to a difference between the rat and the hen. Perhaps cryptoxanthin acts as vitamin A *per se* in the hen and not in the rat.

The provitamin hypothesis may be valid for mammals, but it is incorrect for the hen.

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Microbiological Assay of Amino-Acids with *Leuconostoc mesenteroides P.60*

DUNN *et al.*[1,2,3] have described four different media, varying in their amino-acid contents, for the microbiological assay of amino-acids by means of the lactic organism *Leuconostoc mesenteroides P.60*, and consider that one of these media (medium *D*) is suitable for the assay of lysine and histidine. A re-investigation of medium *D* has shown that in our hands it is inadequate and acid production is poor. Apparently this has also been found by Dunn *et al.*, for in their third communication[3] they recommend the use of 0·05 *N* sodium hydroxide solution instead of 0·1 *N*. In a fourth paper, Dunn *et al.*[4] describe the assay of phenylalanine with a further modification of the medium, in which a still weaker standard solution (0·028 *N*) is used for titrating the acid produced, although in the assays the contents of six tubes were combined and titrated with 0·111 *N* sodium hydroxide.

We have found that a medium containing the following concentrations of amino-acids gave excellent results, with high acid production, equivalent to 14–16 ml. of 0·1 *N* sodium hydroxide.

dl-Alanine	1 gm.	*dl*-Lysine monohydrochloride	250 mgm.
l-(+)Arginine monohydrochloride	250 mgm.	*dl*-Methionine	100 ,,
dl-Aspartic acid	800 ,,	*dl*-Norleucine	100 ,,
l-(−) Cystine	100 ,,	*dl*-Norvaline	100 ,,
l-(+) Glutamic acid	500 ,,	*dl*-Phenylalanine	100 ,,
Glycine	100 ,,	*l*-(−)Proline	100 ,,
l-(−)Histidine monohydrochloride	100 ,,	*dl*-Serine	100 ,,
dl-Isoleucine	200 ,,	*dl*-Threonine	500 ,,
l-(−)Leucine	100 ,,	*dl*-Tryptophan	100 ,,
		l-(−)Tyrosine	100 ,,
		dl-Valine	200 ,,

These amounts are sufficient to make up 1 litre of medium. The other constituents are added in the same concentrations as in medium *D* of Dunn *et al.*

It was further found that folic acid was not an essential nutrient for this organism, although its presence did cause slight stimulation. The remaining vitamin supplements recommended by Dunn *et al.* were found to be adequate. With this modified medium we have been able to assay the following amino-acids: methionine, lysine, phenylalanine, aspartic acid and proline, using *L. mesenteroides P.60*. Details of the assays will be published elsewhere.

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Assay of the Biological Value of a Protein by its Effect on Liver Cytoplasm

IT has previously been shown[1] that the amount of cytoplasm present in the liver is dependent both on the quality and quantity of the protein of the diet. Liver cytoplasm may be determined either by estimating the sum of the protein, phospholipin and nucleic acid contents of the liver or by estimating the non-glycogen non-lipid liver solids. It was suggested at the time that the determination of liver cytoplasm by means of the non-glycogen non-lipid solids may lend itself to a simple and rapid assessment of the biological value of a protein. Since then, investigations have been in progress in this laboratory with the view of developing a suitable method. The most important results obtained from a large number of tests have already been reported[2,3], and a detailed paper is being prepared for publication.

In a communication just published, Harrison and Long[4] also followed up the suggestion made by us in 1944 and fully confirmed the data given in our previous papers on casein, egg albumin, zein and gelatin, and extended them to lactalbumin, gliadin, to casein supplemented by methionine or cystine and to whole egg and whole liver proteins. Their method is based on the regeneration of the protein (total *N*) of the rat's liver following a forty-eight hours fast.

Two methods have been developed in this laboratory during the last year: in the first, the rats are transferred from the stock diet to the test diet for one week, thus measuring the ability of the protein being tested to *maintain* the non-glycogen non-lipid liver solids (labile liver cytoplasm); in the second method, the rats are first given a protein-free diet for four days, during which period their livers are completely deprived of their labile cytoplasm, and then transferred to the test diet for another four days, thus measuring the ability of the protein being tested to *form* labile liver cytoplasm. The results obtained by the two methods are not significantly different.

One fact emerged from these experiments at an early stage[3]. The amount of labile liver cytoplasm depends not only on the quantity and quality of the dietary protein but also on the quantity of food consumed. It was found that unless food corresponding to not less than 26–27 cal./100 gm. body-weight is consumed daily, the maximal effect of the dietary protein on liver protein or cytoplasm is not obtained. In Harrison and Long's experiments, the calorie intakes of the rats fell considerably short of this level. This would account for the fact that they obtained no regeneration of liver protein on 10 per cent casein or lactalbumin diets, while in our experience, with a sufficient calorie intake, considerable amounts of labile liver cytoplasm are formed on a 4·5 per cent casein diet. It is often impossible to increase the protein intake beyond 10 per cent or thereabout, either because the proteins are not readily available in high concentration, as is the case with the mixed flour proteins, or because they are so little palatable, as for example certain protein hydrolysates, that the rats will not take them in concentrations higher than 10 per cent.

We have found that the amount of non-glycogen non-lipid solids (labile cytoplasm) present in the liver is directly proportional to the logarithm of the protein intake. It is thus possible to construct straight regression lines for the different proteins. The regression lines for egg albumin and casein are almost identical, while that for zein has approximately the same slope but lies at a much lower level of liver cytoplasm. Reduction of the calorie intake to 75 per cent decreases the 'biological value' of casein to about that of zein supplemented by tryptophan or that of the mixed soya bean proteins, while reduction to half brings the regression line for casein down to the level of that of unsupplemented zein.

We have used our methods for the assay of protein hydrolysates prepared for therapeutic purposes and for the evaluation of the amount of tryptophan necessary for supplementing acid-hydrolysed casein. Further, the biological values of the protein of 70, 80 and 85 per cent extraction flour have been assayed: a suggestive but not significant difference was found between the 70 and 85 per cent extraction flours when the values were calculated in terms of nitrogen ingested. When, however, the lower digestibility of the 85 per cent extraction flour was taken into account, its biological value became just significantly higher than that of the 70 per cent extraction flour. These results are in general agreement with those of Henry and Kon[5], who used the 'balance sheet' method, and with those of Chick, Copping and Slack[6], who used the 'growth method'.

An investigation into the part played by the individual essential amino-acids in the maintenance and formation of labile liver cytoplasm is in progress in this laboratory.

Grants for scientific assistance and expenses made by the Medical Research Council to one of us (H. W. K.) are gratefully acknowledged.

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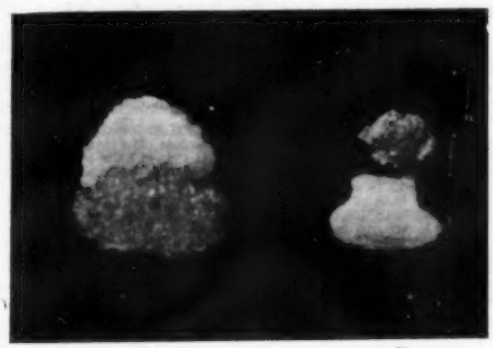
In vitro Grafts

IN 1935, Gautheret[1] published an account of *in vitro* grafts he had obtained between fragments of cambium of *Populus nigra*, *Salix caprea* and other trees, excised and cultured on artificial media. In attempting to repeat this work, I encountered some difficulties when tissues freshly removed from the plant were employed. With cambial cultures of longer standing, however, union *in vitro* was obtained easily. Fig. 1 *a* shows two excised fragments of cambium from *Vinca rosea* as they appeared after two weeks culture on nutrient agar. Regeneration of callus was controlled by the natural polarity of the fragment. After these two fragments had been placed in close contact for three weeks, they were found to be firmly united (Fig. 1 *b*). The union was accompanied by an increased proliferation in other portions of the excised fragment.

(*a*) (*b*)

Fig. 1. CULTURES OF CAMBIUM FROM *Vinca rosea*: (*a*) BEFORE, AND (*b*) AFTER THEIR UNION *in vitro*. (PHOTOGRAPH BY J. A. CARLILE.)



(*a*) (*b*)

Fig. 2. (*a*) CROWN GALL TUMOUR TISSUE GRAFTED ON TO NORMAL *Helianthus* TISSUE, SHOWING DISORGANISED PROLIFERATION INDUCED IN 'STOCK' BY GROWTH-FACTORS PRODUCED BY TUMOUR TISSUE. (*b*) UNSUCCESSFUL GRAFT SHOWING DEAD TUMOUR TISSUE AND NORMAL APPEARANCE OF THE 'STOCK'. (PHOTOGRAPH BY J. A. CARLILE.)

Fig. 2 shows the result of grafting bacteria-free crown gall sunflower tissue, kindly provided by Dr. P. R. White[2], on to a stem culture of normal sunflower tissue. The general appearance of such grafts after four weeks growth is shown in Fig. 2 *a*. The tumour tissue developed as a white, structureless mass, initiating, as it grew, a rapid but disorganised type of growth in the normal stock. The brown discoloration of the cortical cells in this tissue and their swollen hyperhydric appearance resembled the effect produced on normal *Helianthus* tissue by concentrations of indole acetic acid higher than 10^{-4}, suggesting that this substance or one similar in physiological effect is produced and transmitted by the actively growing tumour tissue. One of the grafts in which union did not take place is shown in Fig. 2 *b*. Here the normal stock is firm, white and retains its original organisation; the dead, dried-up tumour tissue is still attached to one side of the 'stock'.

These experiments suggest that the technique of *in vitro* grafting may be of special value as a means of demonstrating growth hormones produced by various types of living tissue, in addition to throwing new light on the actual mechanism of graft unions. Details of experimental technique will be published elsewhere.

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Fractionation of Human Plasma with Ether

IN treating plasma from time-expired blood according to the method described by McFarlane[1] for the removal of lipoid from human serum, it was found that in addition to extracting lipoid from combination with plasma protein, the fibrinogen was also removed. The quantitative removal of fibrinogen was effected by adjusting the plasma with citric acid to *p*H 5·4 prior to freezing to − 30° C. with excess ether. Solutions of extracted plasma protein obtained in this manner, after the removal of the dissolved ether and readjustment to *p*H 7·0, have provided a satisfactory transfusion fluid, remaining crystal clear for more than two years[2].

The fibrinogen obtained by this treatment was in an intractable form, which precluded its recovery for such clinical uses as have been developed by E. J. Cohn and his colleagues[3]. The ether method has therefore been reinvestigated[4].

Blood taken into a trisodium citrate anticoagulant is cooled to 1° C. and centrifuged within 24 hours. The separated plasma is clarified through paper pulp at 1° C. to remove all cellular material. Fibrinogen is precipitated by the addition of 11 vol. per cent of ether, while the temperature is maintained at 0° to − 0·5° C., and allowed to settle overnight at this temperature. The clear supernatant fluid is syphoned off, so far as possible, and the sedimented material removed by centrifuging at 1° C. The precipitate contains 90 per cent of the plasma fibrinogen, and electrophoresis of a solution indicates that fibrinogen accounts for 40 per cent of the total protein.

The greater proportion of the plasma protein occluded in the initial fibrinogen precipitate can be removed by suspending the precipitate in citrate-saline containing 10 vol. per cent ether at 1° C. and recentrifuging. Further purification can be effected by dissolving the washed precipitate in citrate-saline and reprecipitating with ether. Electrophoretic examination of this material at *p*H 8 shows that all the albumin and globulins have been removed, but on prolonged electrophoresis the fibrinogen curve becomes asymmetrical owing to the separation of a material of slightly higher mobility than the main component.

The supernatant from the original fibrinogen precipitation is adjusted at 1° C. to *p*H 5·3–5·4 with 0·2 *M* citric acid, and allowed to stand overnight at this temperature. A yellow precipitate containing prothrombin equivalent to a yield of 40,000 units/litre plasma settles out, and is separated in a manner similar to that described for the fibrinogen. It is washed twice by suspending in distilled water at 1° C. and recentrifuging, to remove substances present in plasma which tend to cause a considerable reduction in the yield of thrombin during the subsequent conversion of the prothrombin. The washed precipitate is suspended in citrate saline and dissolves completely when adjusted with 0·2 *M* sodium hydroxide to *p*H 7·0. On conversion to thrombin with placental thromboplastin at optimal calcium ion concentration, a small amount of fibrin separates, and after removing this a product is obtained with an activity of about 20 units/mgm. protein. The final yield of thrombin is about 25,000 units/litre of plasma. While this thrombin is not of a high degree of purity, it is a satisfactory material for clinical purposes and the solutions obtained contain 150–200 units/ml.

One unit of thrombin is defined as the quantity which in 1 ml. of a fibrinogen solution containing 0·1–0·2 gm./100 ml. will produce clotting in 15 sec. at 37° C.

Following the removal of the prothrombin, the remainder of the plasma is frozen to − 30° C. with excess ether, and during the thawing out the protein is concentrated. The aqueous layer is syphoned off and the dissolved ether removed by allowing jets of air to impinge on the surface of the fluid. The extracted protein solution is adjusted to *p*H 7·0 and diluted to a standard protein content. Traces of fibrinogen which remain in this material are removed by the addition of 0·5 unit of thrombin/ml., followed by cooling to 1° C., when a filmy clot separates. This is made insoluble by freezing to − 30° C. and allowing to thaw slowly. The resulting fluid is clarified and passed through a sterilizing filter. The product is crystal clear, has a pale green tinge, and remains in this condition at room temperature for considerable periods.

The fibrinogen and thrombin preserved by freeze-drying have been used successfully in skin grafting and nerve-suturing operations and in the production of fibrin foam for hæmostasis. The extracted plasma protein residue is a satisf.. tory transfusion fluid.

The whole of this processing is carried out aseptically and no bacterial contamination has been detected at any stage.

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Parthenocarpy and Accompanying Hormonal Syndromes Induced by Unrelated Chemicals

SEEDLESS fruits have been obtained by Gustafson[1] using œstrin and by Wong[2] who used colchicine. Having confirmed[3] the finding of Sass[4] that ethyl mercury phosphate has hormonal and other effects similar to those of colchicine, I compared the effects of colchicine, acenaphthene and ethyl mercury phosphate in the form of 'Ceresan'.

Seeds of cucumber (var. Danish Mustard) were germinated on filter paper moistened initially with a 1 in 1,000 suspension of 'Ceresan' which was reduced tenfold by successive waterings. After about five days the seedlings were potted. When flowering began, the flowers were sprayed with a 1 in 2,000 suspension of 'Ceresan'. Acenaphthene was supplied as a sprinkling of crystals under the moist filter-paper, and just before flowering the flower-buds were enclosed in glass tubes carrying acenaphthene crystals on their walls.

Both acenaphthene and the mercury compound exerted toxic effects under the conditions stated; growth was reduced and roots were thickened. Treated plants flowered later than the controls. Table 1 gives the average numbers of fruit set per plant on a total of 264 plants.

TABLE 1.

Date	Ethyl mercury phosphate	Acenaphthene	Control
Sept. 1	0·14	0·11	0·07
,, 14	0·98	0·28	0·68
,, 20	2·34	1·42	1·32
Oct. 4	2·97	1·67	1·82

Fruits of the 'mercury' series were mostly malformed and much smaller than those of the controls. An attack of mildew caused most of the fruits to be shed: but all 29 of the fruits remaining on the 'mercury' series were parthenocarpic; of the acenaphthene series 18 were parthenocarpic out of 25, while only 2 of 29 control fruits were parthenocarpic.

To tomatoes (var. *Lucullus*) a 0·001 per cent solution of colchicine was administered through a cut in the stem[4] and by repeatedly spraying the flowers with the solution.

More fruit was set, and earlier, in the treated than in the control plants. Results are shown in Table 2.

TABLE 2.

Treatment	Total number of fruits	Total weight of fruits	Av. weight of one fruit	Number of ripe fruits
Colchicine	46	1440·0 gm.	31·3 gm.	29
Control	28	1105·0 ,,	39·2 ,,	18

All the treated fruits except three were parthenocarpic, but none of the control fruits was. Lenticels of the treated plants were markedly hypertrophic and some treated plants had adventitious roots.

In addition to giving evidence of induction of parthenocarpy by a mercury compound chemically unrelated to substances previously shown to exhibit that property, I want to stress the hormonal effects. Taken together, the findings confirm the suggestion[5] that there is essentially a common mechanism at work, namely, a disturbance of the vertical polarity of translocation of endogenous hormones and of the hyper-compensations resulting therefrom.

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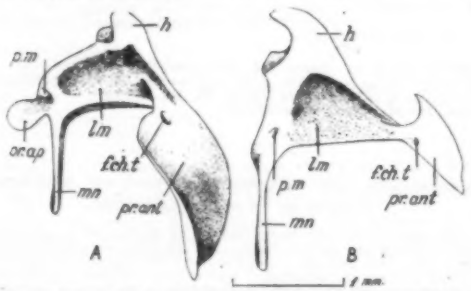
Anterior Process of the Malleus in Rodents

A LARGE anterior process of the malleus (processus gracilis, folianus, or longus of various authors) is known to occur in Monotremata, Marsupialia, Insectivora, Edentata, and Chiroptera[1-3]. The process is much reduced in higher mammals[2]. In an investigation of the tympanic region of some mammals it was found that most Egyptian rodents possess a large anterior process of the malleus which in adult individuals completely fuses with the tympanic bone. The process is perforated for the passage of the chorda tympani and may project with a free extremity on the ventral surface of the skull between the bulla and the base of the squamosal. A very long and broad process has been found in *Mus musculus* (Fig. 1*a*), *Rattus rattus*, *R. norvegicus*, *Acomys cahirinus*, *A. russatus* and *Arvicanthis niloticus* (Muridæ). The process is short and broad in *Gerbillus pyramidum* (Fig. 1*b*), *G. gerbillus*, *Meriones libycus*, *Pachyuromys duprasi* and *Psammomys obesus* (Gerbillinæ). It is long and narrow in *Allactaga tetradactyla*, adze-shaped in *Jaculus jaculus* and *J. orientalis* (Dipodinæ), and is much reduced in *Oryctolagus cuniculus* (Leporidæ).



LEFT MALLEUS OF *Mus musculus* (*A*) AND OF *Gerbillus pyramidum* (*B*). INTERNAL VIEW: *f.ch.t.*, FORAMEN FOR CHORDA TYMPANI; *h.*, HEAD; *lm.*, LAMINA; *mn.*, MANUBRIUM; *or.ap.*, ORBICULAR APOPHYSIS; *p.m.*, PROCESSUS MUSCULARIS; *pr.ant.*, ANTERIOR PROCESS.

Gaupp[2] states that the anterior process of the malleus in mammals is formed by a dermal bone, the homologue of the reptilian gonial (prearticular). Ridewood[4] says that cartilage-bone enters largely into its composition, and De Beer[5] expresses the view that the process is primarily a part of the malleus representing all that is left of its connexion with Meckel's cartilage, ossifying as cartilage-bone to which the prearticular subsequently becomes fused. The results so far reached from the study of alizarin-stained specimens of a number of embryonic and post-embryonic stages of *Hemiechinus* (Insectivora), *Rousettus* and *Tadarida* (Chiroptera), *Mus* and *Gerbillus* (Rodentia) are in agreement with Gaupp's view. In all these genera the part of Meckel's cartilage opposite the gonial does not ossify and takes no part in the composition of the anterior process of the adult malleus, which appears to be formed solely by the gonial. The process of ossification of the malleus starts in the gonial and proceeds into the lamina and head of the developing malleus; the manubrium ossifies later.

Although a gonial has been described in the embryo of *Mus* by Fuchs[6] and of *Lepus* by Voit[7] no reference has been made to it in rodents' mallei so far described by various authors.

Full details of this study will be published elsewhere.

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Bias in the Use of Small-size Plots in Sample Surveys for Yield

SAMPLE surveys for yield of cotton, wheat and paddy conducted in recent years all over India (except Bengal) have been carried out on plots of large size varying from 1/160 to 1/20 of an acre[1-3]. In contrast, the plot size used in Britain and the United States is small, of the order of 1/4,000 of an acre[3-4]. In India the small-size plot (area 13·6 sq. ft.) was first used by Hubback and in recent years by Mahalanobis[4-6].

An investigation was carried out in the Moradabad district (area 2,288 sq. miles) for comparing different size plots. The plan of sampling was similar to that used earlier[1-3], except that in each selected field eight plots were marked at random: (*a*) two equilateral triangular plots of side 33 ft. subdivided into three strips by means of lines parallel to the base at distances of 8¼ ft. and 16½ ft. from the vertex along the sides; (*b*) three circular plots of radius 2 ft. each; and (*c*) three circular plots of radius 3 ft. each. The triangular plots were marked with the help of chains and pegs and the circular ones with the help of a specially devised apparatus consisting of a peg, a steel tape and a plumb line. The investigation was carried out by the staff of the Department of Revenue posted in the district, who ordinarily are required to carry out these experiments under official orders.

Size of plot in sq. ft.	No. of plots	Average yield in maunds per acre	Percentage over-estimation
Irrigated			
471·5	78	10·10	
117·9	78	10·58	4·8
29·5	78	11·69	15·7
28·3	117	11·60	14·9
12·6	117	14·38	42·4
Unirrigated			
471·5	107	6·55	
117·9	107	7·27	11·0
29·5	107	8·08	23·4
28·3	162	7·52	14·8
12·6	161	9·33	42·4

The accompanying table shows the results. It will be seen that small plots (less than 30 sq. ft.) result in a serious over-estimation of yield. The bias diminishes with increase in the size of plot, but even plots of 118 sq. ft. are not free from bias. The differences in the yield estimates are found to be statistically significant. Not only are the results consistent both for irrigated and unirrigated wheat, but also they show the same trend of bias in all the six tehsils in which experiments were carried out. The field staff employed was different everywhere.

Yates has previously reported the existence of bias from the use of small-size plots[7]. The reason for over-estimation appears to be the human tendency to include border plants inside the plot. This factor becomes serious when the perimeter of the plot is large in proportion to its area. In another scheme in Madras, a comparison was made between the estimates from 1/20 acre plots and the whole field, and the two agreed within the margin of their sampling errors. These results indicate that in India, where crops are unevenly sown, and possibly also in Britain and the United States, small-size plots most probably lead to biased results.

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PRESENT STATE OF SOME GERMAN MUSEUMS

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HAVING been granted special facilities to visit German museums during the last few months, it may interest readers of *Nature* to read my notes made from first-hand observation. The information is of necessity scrappy in view of the almost inconceivable chaos now existing in German transport and communications. One lasting impression remains with me: the certainty that it will be many years before anything approaching normal conditions returns to German museums. The destruction of buildings must be seen to be believed, and one may be excused for thinking that there is a good case for abandoning towns such as Cologne, Frankfurt, Stuttgart and others and building new towns on alternative sites.

By and large, scientific collections have emerged from the War with relatively little damage since for the most part they were evacuated in time. It has certainly been proved that such a policy was wise. Exhibition collections and teaching material, on the other hand, have usually suffered the fate of the museum or university building in which they were kept, while 'souvenir-hunting' has added to the losses.

Frankfurt on Main: Senckenberg Museum

The buildings are very seriously damaged, having been burned out and hit by high explosive bombs on several occasions.

The director is Dr. Rudolph Richter, who is at present (November 1945) interned in Bucharest, where he was on a visit when the Russians entered the town. Certain of the staff are still there.

The collections, apart from those on exhibition, were evacuated to more than forty different places and all but one of these escaped damage, the one being completely destroyed. The depot which is destroyed contained part of the collection of Mollusca, Aves, Palæontology and Palæobotany.

Each evacuation depot contained parts of several sections of the collection, it being considered that by this means no single section would suffer total loss in the event of damage being caused.

The Library was also evacuated and is reported to be safe.

Publication of the Senckenberg periodicals continued right throughout the War and a number of manuscripts are now in hand ready for publication. All that is lacking is permission to publish and a supply of paper. I brought back with me a set of the publications.

Frankfurt on Main: Zoological Gardens

The Zoological Gardens have suffered severely but part is now (November 1945) open to the public and there is a daily circus performance. The director is Dr. Bernhard Grzimek and the superintendent Herr G. Lederer (entomologist).

The Aquarium is completely destroyed and its contents lost. The small staff now available are all engaged in dealing with the tremendous difficulties with which they are faced.

The whole Library is destroyed, as also was part of Herr Lederer's private entomological collection, including "about 4 types of Geometridæ" of which I was unable to learn the names. I visited the Gardens and saw two European bison (80 per cent pure), lions, elephants, a camel, hippopotamus, two chimpanzees, several bears, deer, wild boar, etc., and a number of parrots, eagles, vultures, hawks and owls. The collection is small and badly housed, for there is little or no glass available and most of the roofing is inadequate to provide protection against the weather. The surrounding ruins of the almost completely destroyed city of Frankfurt do not improve the picture.

I learned from Lederer that the entomologists G. Ochs and Prof. E. May were interned by the Nazis at Dachau but they are thought to be still alive.

Wiesbaden: Landesmuseum für Naturkunde

The building is little damaged and much of the collection is stored there still but is not available, as the building is under requisition by the Americans for use as a clearing house for the stolen works of art they have discovered. I was fortunate in being allowed to see some of the priceless contents of the building. This included (October 1945) an immense collection of church treasures stolen by the Germans from Poland (mainly the neighbourhood of Poznan), St. Stephen's crown from Hungary, the remainder of the Prussian State jewels and the old masters evacuated from the Berlin museums and galleries.

In passing, I would record the great difficulty being experienced by the American officer in charge, Capt. Farmer, in identifying many of the objects stolen by the Germans from Poland, for many are not recorded in print.

The Library of the Museum is intact and has apparently suffered no damage. It is in a certain state of disorder as the result of its removal to and from the cellar and, I imagine, the present lack of trained staff. It should not, however, come to any harm under present conditions.

Darmstadt

The town is as badly damaged as almost any in Germany, and was obviously completely burned out. I failed to find any scientific workers: for that matter there are extremely few people in the town at all. The Museum was destroyed but whether or not the contents had earlier been removed I was unable to learn.

Heidelberg

This was the first town I had seen in the course of much travelling in Germany that was completely undamaged with the exception of the river bridges.

I called at the Natural Science Department of the University, but only a single naturalist had returned and I omitted to note his name. I understand that what collections they had are undamaged, and the Geological Library, which I saw, is in perfect order. The University Library is occupied by an American service organisation and I was unable to visit the book stacks. The Heidelberg Academy of Sciences continued its publications throughout the War and I obtained a set which I brought to London.

Karlsruhe: Technische Hochschule

The buildings have been extensively damaged and are now (November 1945) an empty shell. I failed to find anyone but a caretaker, who could give me no information. Despite prolonged inquiry, I failed to locate the present whereabouts of the Geologisches Landesanstalt.

The Museum building is totally destroyed and here also I failed to trace any person with exact information. I managed to seek out the publication store room and obtain a set of publications which I brought back to London. I could not discover whether or not the collections are now safe, but there is nothing in the Museum itself.

Stuttgart Museum

The building is burned out. The present director is Dr. M. Rauter, and Dr. E. Lindner and Dr. Götz (both entomologists) are still at the Museum, the latter having just (November 1945) returned from service.

The collections have suffered severely and the exhibit specimens and collection of invertebrates are completely lost, according to Dr. Rauter.

The most valuable part of the entomological collection was evacuated to a salt mine at Kochendorf, where it now (November 1945) is, and many other parts of the collections were deposited in various castles in the neighbourhood of Stuttgart. It is thought that no types have been lost.

Dr. Götz told me that no parts of the *Orthopterorum Catalogus* appeared during the War.

Herr Kernen, of Kernen-Verlag, who is a Swiss subject, is now in Switzerland, and Herr Cellarius acts as his agent. The stock of publications has been lost except for certain parts of Seitz, "Grosschmetterlinge der Erde", which appeared during the War, and these, while safe, are inaccessible. I understand that copies for British libraries have been put on one side and are safe.

I saw Herr Obermuller, of Schweitzerbart'sche Verlag, who told me that the firm had suffered little or no loss of stock and that publication had continued throughout the War. I collected a set of such publications as were immediately available and brought them to London, including a copy of Lindner's "Die Fliegen". Obermuller complained that he was unable to obtain a permit to publish from the Americans and sought to induce me to bring pressure to bear on them to permit him to start up again. I understand that he has a number of manuscripts awaiting publication.

Coblenz

This town is very heavily damaged and I was unable to locate any men of science or scientific institutions.

Mainz

This town is also very heavily damaged and I was again unable to locate any scientific workers or scientific institutions.

Dusseldorf

This town is also heavily damaged except for the suburb of Ober-Kassel. I was unable to find any scientific workers or scientific institutions.

Duisburg

Here again damage is heavy, but I found the Staatliche Kunst Museum building little damaged and (November 1945) in use for office purposes. Evidently the collection had been evacuated, but I could discover no details. The Niederrheinisches Museum, on the other hand, is completely wrecked. What was evidently once a small compact building is now an empty shell open to the sky and with nothing but debris for its contents.

Köln

Cologne is a terrible sight—a ruined city!

The Zoological Gardens are very badly damaged but a small collection remains. The director is Dr. W. Zahn, who told me that Prof. Otto Kuhn was at present in the city (November 1945), but since he had been a member of the Nazi party he was no longer in office. Herr Ernst Schäfer, the Tibetan traveller, was an ardent Nazi and had joined the S.S., but Zahn had no news of his present whereabouts.

In the menagerie I saw a three-year-old hippopotamus (born in Amsterdam), two zebras, a reindeer, three antelopes, a camel, llama, wild horse, wild boar, Indian buffalo, water buffalo, porcupine and a yak, two dwarf Serbian asses and six wild sheep. All are kept in unsatisfactory conditions, without adequate food supplies.

Bonn

The Geologisch–Paleontologisches Institut building is undamaged. The present director (November 1945) is Prof. Hans Cloos, and the following staff are safe: Prof. J. Wanner, Prof. N. Tillman, Prof. E. Jaworski and Dr. W. Bierther. Dr. G. Knetsch is still a prisoner-of-war in Norway and I was told that Prof. C. Troll is alive and his large private library safe. Dr. W. Kleber is well, and Prof. K. H. Schaumann of Leipzig is going to Bonn to replace Prof. K. Chudoba, the former head of the Mineral Department, who has been removed from office as he was an ardent Nazi. Chudoba is said (October 1945) to be in prison in Elberfeld.

The geological collection is undamaged but the mineral collection is estimated to be 60 per cent destroyed.

The Zoologisches Institut building is completely destroyed. The present director, Prof. A. Reichensperger, told me that the entire collections are lost. He mentioned in particular the Winnertz collection of Diptera, including types, part of the Nees von Esenbeck collection of Hymenoptera, including types, the large Bruch collection of local Coleoptera, the bird collection, the mammal collection and all teaching material. In addition, some 10 per cent of Reichensperger's own collection of Myrmecophiles, including some types of Histeridæ, are destroyed.

Dr. E. Schmidt, the entomologist, is alive, and I called at his house to find him out shopping—a major preoccupation of Germans to-day!

The Museum König (now Reichsmuseum König)—formerly a private collection—has been acquired by the State and the present director is Dr. von Jordans, an ornithologist. The building has been damaged, but not seriously, and the collections, including Hone's Chinese material, are safe.

The Landesmuseum is a burned-out shell.

Krefeld

The original premises of H. Goecke Verlag are much damaged and the proprietor, Herr Goecke, has entered into a partnership with a Dutch coleopterist named Evers. The stock of *Entomologischer Blätter* is largely destroyed, but I was able to obtain a set of the war-time issues, which I brought to London. Goecke's private library is safe. There is no museum in Krefeld so far as I could ascertain.

Berlin

Das Deutsches Zoologisches Museum (formerly Zoologisches Museum der Universität) is very heavily damaged. The present (November 1945) directors are Prof. H. Bischoff and Prof. H. Pohle, who were appointed by the Russians. The staff comprises, in addition, Prof. M. Hering, Prof. W. Ramme, Dr. H. Hedicke (Rhynchota), Herr N. I. Kardakoff (Lepidoptera), Dr. K. Delkeskamp (Invertebrates), Dr. M. Eisentraut (Arachnida), Dr. Hahn (Vermes), Herr Grote (Aves) and Prof. E. Stresemann (Aves). The former director, Prof. von Lengerken, was a Nazi and has been removed from office, although I understand he is still at work in the Agricultural High School. Dr. Stichel, the hemipterist, was responsible for giving away a number of his colleagues to the Nazis and was directly responsible for the beheading of Prof. Arndt (sponges) a year or two ago.

The Museum was declared an independent institute, free from the University, by the Russians in September 1945.

The following workers are stated to be alive (November 1945): Prof. Schellenberg (Crustacea), Herr Friese (entomology), Herr Bluthgen (entomology), Herr Hans Wagner (entomology), Prof. G. Enderlein (entomology). The following workers are, I understand, dead: Herr Alfken (entomologist), Herr Max Muller (entomologist), Herr Engel (dipterist), Herr Draudt (lepidopterist), Herr Urbahn (entomologist), Herr Hennig (entomologist), Prof. Pappenheim.

The collections are partially destroyed (estimated loss in entomology one fifth) but the main part is safe.

In addition to the museum collections, the well-known collection of leaf-miners owned by Prof. Hering has been completely destroyed but fortunately many of the bred insects are safe. Prof. Hering told me that the Staudinger Collection, including the Micro-lepidoptera, is safe.

The Museum Library was evacuated to Altlitz-on-Oder, but, shortly before the Russian advance, Prof. Stresemann managed, by using military transport, to return most of it to Berlin, where it now is. Only six cases with their contents are lost and these are known to have been burned. The Museum building is very seriously damaged and while some rooms are still in use, this is only because there is a complete lack of alternative accommodation in Berlin. So far as I can discover (November 1945), no scientific work is being carried on at the Museum; nor, under existing conditions, is it possible, but some specialists are continuing to work at home. In my view, there is serious danger of grave damage occurring to those parts of the collection and library now in the Museum building from the effects of the weather. Several inches of water were lying on the ground floor when I arrived (it had rained during the night) and there is practically no glass anywhere and almost no cardboard or other material available, and there are few doors in the building. Books and papers are blowing about in some of the rooms and the windows afford no protection from wind and weather. The whole efforts of the small staff now available are devoted, under the most trying conditions imaginable, with no heating and very small personal food rations, to preserving what is left of the contents of the Museum. The measure of their success remains to be seen.

Dr. Hedicke suffered great personal loss. His home and its contents were destroyed by a direct hit from a bomb. That part of his collection at his home at that time was destroyed, but he had, as a precaution, stored some valuable parts of it elsewhere and unfortunately this suffered a like fate. I understand that no part of his collection, or any insects on loan to him, have been preserved.

The building of the Deutsches Entomologisches Institut in Gosslerstrasse is practically undamaged, but the contents are evacuated to Post Blucherhof, Mecklenburg, where they are believed to be safe and sound. The present director is Dr. H. Sachtleben, who is with the collection so far as I can discover. The building is at present (November 1945) occupied by an American military organisation.

Of the Berlin publishers, Friedländer und Söhn is at present owned by Dr. P. Budy. The old premises in Karlstrasse are completely destroyed and that part of the stock which is saved is said to be in Gotha. The firm is now known as 'Natura' Verlag.

The premises of Nicolaische Buchhandlung are a pile of rubble. I did not discover the present whereabouts, if any, of the firm.

The premises of Gebrüder Borntträger are burned out, but I found an alternative address which I visited to find no one in and only a small pile of books visible through the windows.

I understand that J. Springer is still in business at its old address, but I had not sufficient time to call.

The firm of W. de Gruyter is also still at its old address, but again I had no time to call.

Göttingen

The Geological and Palæontological Department of the University is under the direction of Prof. E. Bederke, formerly of Breslau. He is assisted by Prof. Herman Schmidt and Dr. Kremp. Prof. W. Schriel and Dr. Thienhaus were both Nazis and neither is now allowed to work in the University. The former is in Göttingen and the latter somewhere in the country.

About two thirds of the building is unusable and the collection is much damaged. Prof. Bederke estimates the loss at about 20 per cent, and many original specimens (types) have been destroyed.

Both the building and collection of the Anatomical Department are completely destroyed.

The library of the Naturwissenschaftlisches Institut was evacuated to a salt mine at Wolprie-hausen and shared the mine with a munition dump. Unfortunately this blew up and several thousand works are believed to have been lost. The exact extent is unknown, for the mine is still sealed up.

The dean of the Natural Sciences and Mathematics Faculty of the University is now Prof. Eucken and the following are the staff: *Botany:* Prof. Harder (director), Prof. Steiner, Dr. von Witsch, Dr. von Denffer; the building and collections are all undamaged. *Zoology:* Prof. Henke (director) and Dr. von Holst; the building is a total loss, but the collection, which was partly in the cellar and partly evacuated, is undamaged.

The meteorologist, Prof. Angenheiter, died a few months ago, and Dr. von Engelhardt, the mineralogist, was an old member of the Nazi Party and is now a prisoner in Wuppertal.

The president of the Göttingen Akademie der Wissenschaften is Prof. Correns, with whom I spoke on the telephone and who promised me a set of the publications of the Academy. Unfortunately his assistant would not produce them for me and I left the next day without them.

THE MATHEMATICAL ASSOCIATION

A GENERAL meeting of the Mathematical Association was held at the Polytechnic, Regent Street, London, during April 24 and 25, under the presidency of Prof. Sydney Chapman, chief professor of mathematics at the Imperial College of Science and Technology until his recent election to the Sedleian professorship of natural philosophy at Oxford. The annual report of the Council was adopted, and the officers for the ensuing twelve months elected; the new president is Mr. W. F. Bushell, headmaster of Birkenhead School.

The presidential address, "The University Training of Mathematicians", traced the development of mathematics as a principal subject in the university curriculum at Oxford and Cambridge, from the medieval period down to the present day, and also gave an account of the content and organisation of the course in mathematics at the Imperial College. Prof. Chapman gave details of the numbers of university students reading mathematics and the first results of an inquiry into the subsequent careers of such students. Further facts are in process of collection, and it is hoped to gather together such information for most of the universities of Britain, as well as details concerning the organisation and staffing of the mathematical departments.

A discussion on "Geometrical Drawing in the Higher School Certificate Course in Schools" was opened by Dr. W. G. Bickley and Dr. S. Weikersheimer. Dr. Bickley dealt with general principles, urging that opportunities for combining action with thought are rare in the mathematical course in schools, and suggesting that geometrical drawing provides an excellent way of encouraging such a combination. Dr. Weikersheimer gave a clear and thorough account of the teaching of descriptive geometry in Bavarian schools before 1933. The resulting discussion appeared to show that teachers, if in general agreement with Dr. Bickley's ideals, were dubious about the practicability of fitting the details into a course directed towards the higher school certificate.

Mr. D. N. de G. Allen spoke on Southwell's relaxation method in engineering, with special reference to its power of providing numerical solutions of partial differential equations, such as arise in hydrodynamics, elasticity and plasticity.

Mr. D. J. Finney, in a paper on "Statistical Science and Agricultural Research", described the development of the field-plot trial from the original simple plan of dividing a field into a number of plots and applying a different treatment to each plot to the present system of factorial and replicated experiments. The work of the Rothamsted Experimental Station formed the basis of Mr. Finney's address, which demonstrated how pattern problems of abstract mathematics have become of importance in the growing of wheat and potatoes.

A joint paper, "A new approach, by means of isogonal conjugates, to certain geometrical theorems and to a general theory of conics", was presented by Mr. H. E. Piggott and Dr. Alfred Steiner. What, in the 1890's, was called the 'modern geometry of the triangle' has come to be regarded as a blind alley, but Mr. Piggott showed that a use of isogonal conjugates in close connexion with the circumcircle of a triangle can lead to a synthesis of results and a freshness of treatment even in this well-worked domain. Since such results are apparently essentially metrical, it was something of a surprise to find that Dr. Steiner has been able to translate many of them into the language of conic sections, and has thereby been able to exhibit a general theory in a new and elegant fashion. Time did not permit a full exposition of these ideas, but teachers appreciated the fresh outlook, though consideration of detail must wait until the publication of the whole work.

The afternoon of April 25 was devoted to a well-attended discussion on "The Place of Mathematics in Secondary (Modern) Schools". Mr. F. J. Swan opened the discussion and stressed the extreme importance of the problems presented in the organisation of the secondary modern school, through which will pass a very large proportion of the whole school population of Britain. By references to the frequency curve, he warned the Association against paying undue attention to the needs of the small proportion of children with fairly high intelligence quotients and thus doing less than justice to the large majority with intelligence quotients near the mean. Above all, he urged that the mathematical course should be framed about the child—not with eyes on examinations, not even with eyes so much on the subsequent career of the child, but with eyes on the child himself as he is at this stage of his life. Mr. C. T. Lear Caton followed with a clear and instructive analysis of the inferences drawn by him from his knowledge of 'modern school' work in the Midlands. Mr. Caton emphasized the need of the ordinary citizen in the present world for a certain minimum of mathematics with as wide an 'outlook' value as possible, and the need to replan mathematics courses in all types of schools to fit in with the new educational structure. Mr. H. H. Watts described the work recently done by the Yorkshire Branch of the Mathematical Association in attempting to determine a central core of mathematical doctrine which could form a course common to all children between the ages of eleven and thirteen, and on which varying superstructures could later be erected to meet the needs of the later age groups. This would facilitate the process of transfer which is envisaged in the nation's future educational scheme. Details of a syllabus framed for this purpose by the Yorkshire Branch were given.

When the discussion was thrown open, it became evident that there is a very wide variety of opinion among members of the Association. No one doubted that the problems are complex and urgent, that the fullest consideration should be given to all ascertainable facts and all varieties of opinion, that there should be no shrinking from bold and well-conceived experiment; but beyond this general ground, there was little agreement. It was pointed out to advocates of the attractive idea of a 'central core' of mathematics for the eleven to thirteen stage that this would tend towards undue emphasis on the teaching of the small number of possible transfer pupils, and not enough on the needs of the very much larger number who will not require transfer from the secondary modern school to schools of other types. On points of syllabus there was general agreement that mathematics must be taught as a unity, not as a set of watertight compartments of arithmetic, algebra and geometry; but there was an evident difference of opinion on how far this unifying process can be carried. A strong plea for a fundamental place to be given to spatial concepts in the early stages of mathematics was met by an equally strong insistence on the primary value of the number concept. When time-table considerations

compelled the closing of the discussion, it was with regret that members left so vigorous a debate on so vital a topic.

The final paper described the past history and the present policy and aims of the Association's journal, *The Mathematical Gazette*; in this address, the editor, Mr. T. A. A. Broadbent, referred particularly to the great work done for the Association by his predecessor, Mr. W. J. Greenstreet, editor of the *Gazette* for more than thirty years.

The Teaching Committee of the Association, at its general meeting on April 26, paid much attention to the subject of the 'modern' school; the Committee is anxious that every aspect of mathematical teaching in such schools should be thoroughly surveyed, and that all information and opinion on this topic should be carefully studied. A strong sub-committee has been set up, charged with the duty of making a full and thorough investigation into, and a report to the full Committee on, this vital and urgent problem of mathematical teaching.

FLORA OF EGYPT

THAT Egypt is 'the gift of the Nile' may be true from the point of view of human civilization but such a phrase would be misleading if applied to the plant-life of the country. Even the weed flora of the canals and cultivated land is not uniform, and to this must be added the ephemeral flora of the deserts, and the mountains and mountain valleys of Sinai and the Elba mountains. Many botanists have explored Egypt and much has been published regarding both the wild and cultivated flora. However, the need for an accurate and up-to-date taxonomic account cannot be gainsaid, and the present work* by Mrs. Täckholm and the late Prof. G. Täckholm is intended to meet this need.

The first volume (dated 1941) is a mine of information concerning the Pteridophyta, Gymnospermæ, and, following Engler's classification, the monocotyledon families from Typhaceæ to Gramineæ, recorded in the wild or in cultivation within the political boundaries of Egypt. The descriptions given are short, but there are keys to genera within the families and to the species of the larger genera. The known distribution within Egypt is given very fully with the general distribution in outline. There are a large number of habitat notes and very full bibliographical references.

Particular attention should be directed to two or three special features, some of which are very exceptional, or even unique, in a Flora. All plants known to be cultivated, agriculturally or horticulturally, in Egypt are included, often with very full accounts and numerous extracts, references, and comments. The account of the sugar cane, for example, occupies thirteen pages. The 'tomb flora' is also dealt with at length, with detailed documentation for the families included in this first volume. Thus the wheat of Ancient Egypt is discussed at length—forty-three pages are devoted to the genus *Triticum* altogether.

One cannot help feeling that the fundamental purpose of a Flora—for use in determining quickly and accurately the names of plants growing in the area covered—is here overwhelmed by the results of most diligent and energetic bibliographical research. This first volume, of 574 pages, only includes probably somewhere about one tenth of the species of vascular plants growing in Egypt. The completion of the Flora on the same scale and to the same standard will make a bulky work. It would appear to the reviewer that a completed one- or two-volume work restricted to the wild flora and its taxonomy would better have met immediate needs and this could then have been followed by as many special volumes as were needed to deal with the cultivated plants, the tomb flora, and so on, as at great a length as the authors thought necessary. It seems a mistake to combine a 'Flora of Egypt' with an 'encyclopedia of Egyptian botany'. The result will be a work too cumbersome for use in the field and, apparently, a long interval before its completion.

W. B. TURRILL.

* Flora of Egypt, vol. 1. By Vivi and Gunnar Täckholm, in collaboration with Mohammed Drar. Cairo: Fouad I University, *Bull. Fac. Sci.*, No. 17, pp. 574 (1941).

BLOOD CELLS OF AN INSECT

J. FRANKLIN YAEGER of the U.S. Bureau of Entomology and Plant Quarantine (*J. Agric. Research*, 71, 1; 1945) has prepared a very detailed paper on this subject. Under the title of "The Blood Picture of the Southern Armyworm (*Prodenia eridania*)", the hæmocytes of this species of caterpillar are described, identified and classified. Also their incidence and changes at different stages in the development of the insect were noted. The blood cells or hæmocytes of insects, it may be added, are analogous to the leucocytes of vertebrates and form part of the defence mechanism against bacteria and other foreign bodies. There is evidence that the functions of these cells may be changed by the action of insecticides, but little progress is likely to be made as regards this problem until we know more about insect hæmocytes in general.

The author claims that in the southern armyworm the blood cells fall into ten classes, which he subdivides into no fewer than thirty-two different types. He finds that existing systems of blood-cell classification are too far simplified to be of much help in identifying the hæmocytes of the armyworm. The early caterpillar is characterized by the predominance of primitive and perhaps embryonic types of blood cells. The late caterpillar has a marked development of special larval hæmocytes which reach their maximum in numbers and development about the beginning of pupation and disappear during the pupal stage. The imago is characterized by the development of the imaginal hæmocytes. The interrelationships of the different types and classes of blood cells are discussed and displayed in a schematic diagram.

The known functions of these various cells are summarized by the author as follows: (1) phagocytosis, (2) participation in hæmolymph coagulation, (3) agglutination *in vivo*, including the formation of capsules, (4) plastid formation, (5) eruption or sudden liberation of material into the plasma under certain conditions, and (6) glycogen storage. The paper is illustrated by numerous colour photographs (Kodachrome) of preparations made of smears stained with Wright's blood stain. In almost all cases a 93 × objective (oil immersion) and a 10 × ocular were used.

FORTHCOMING EVENTS

Saturday, May 11

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting. Mr. G. F. Laycock: "Mineral Exploration and the Outlook for Metal Supplies" (Presidential Address).

Tuesday, May 14

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 1.30 p.m.—Dr. Iorwerth C. Peate: "Welsh Musical Instruments".

ZOOLOGICAL SOCIETY OF LONDON (joint meeting with the BRITISH ORNITHOLOGISTS' UNION, at Regent's Park, London, N.W.8), at 5 p.m.—Scientific Papers.

INSTITUTION OF CHEMICAL ENGINEERS (joint meeting with the CHEMICAL ENGINEERING GROUP, at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. D. J. Full: "Instrumentation in Plant Control".

Monday, May 13—Tuesday, May 14

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1).—Conference on "Certain Aspects of the Action of Radiation on Living Cells".

Monday, May 13

At 9.45 a.m.—Physical Introduction; "The Action of Radiation on Viruses"; at 2 p.m.—"The Action of Radiation on Aqueous Solutions".

Tuesday, May 14

At 9.45 a.m.—"The Action of Radiation on Chromosomes"; at 2 p.m.—"The Effects of Radiation on Germ Cells, with special reference to Man".

Wednesday, May 15

ROYAL METEOROLOGICAL SOCIETY (joint meeting with the BRITISH ECOLOGICAL SOCIETY, at the Royal Society, Burlington House, Piccadilly, London, W.1), at 2.15 p.m.—Discussion on "Ecology and the Study of Climate".

PHYSICAL SOCIETY, LOW-TEMPERATURE GROUP (in the Department of Chemical Technology, Imperial College, Prince Consort Road, London, S.W.7), at 3.45 p.m.—Sir Alfred Egerton, F.R.S., and Mr. M. Pearse: "Storage of Liquefied Gases"; at 4.35 p.m.—Dr. T. A. Hall: "Liquefaction in relation to Gas Manufacture".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 5 p.m.—Prof. C. S. Gibson, F.R.S.: "The Life and Work of Sir William Jackson Pope, K.B.E., F.R.S." (Sir William Jackson Pope Memorial Lecture).

ROYAL INSTITUTE OF CHEMISTRY (at the Royal Institution, Albemarle Street, London, W.1), at 6.30 p.m.—Dr. G. A. Cowie: "Potash and Crop Production".

Thursday, May 16

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (joint meeting with the SCOTTISH SECTION, at the North British Station Hotel, Edinburgh), at 2.30 p.m.—Discussion on "Spectroscopic Analysis".

PHYSICAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 3 p.m.—Annual General Meeting; at 4 p.m.—Prof. Charles Sadron: "Some Physical Properties of Long-chain Molecules" (First Holweck Discourse).

INSTITUTE OF FUEL, EAST MIDLAND SECTION (in the Demonstration Theatre, Gas Department, Parliament Street, Nottingham), at 5.15 p.m.—Annual General Meeting; at 6 p.m. (joint meeting with the NATIONAL SMOKE ABATEMENT SOCIETY, the SOCIETY OF CHEMICAL INDUSTRY, and other technical bodies)—Mr. S. N. Duguid: "The Prevention of Industrial Smoke".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 8 p.m.—Colonel Thomas T. Mackie: "Observations on Tsutsugamushi Disease (Scrub Typhus) in Assam and Burma".

Tuesday, May 14—Thursday, May 16

ILLUMINATING ENGINEERING SOCIETY (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2).—Convention.

Tuesday, May 14

At 6 p.m.—Reception by the President, followed by Lecturettes on "Lighting in Captivity", "Camouflage and Decoy-Tactics", "Some Light on Invasion", "The Wonders of Black Light", etc.

Wednesday, May 15

At 10.45 a.m.—Annual General Meeting, followed by Addresses on "Lighting during the War and After" and "Light and Health"; at 2.30 p.m.—Mr. J. L. Davies: "New Lamps for Old".

Thursday, May 16

At 10 a.m.—Mr. W. R. Stevens and Mr. G. T. Winch: "Laboratory Technique during the War"; at 11.30 a.m.—Dr. S. English: "Aerodrome Lighting"; at 2 p.m.—Mr. W. A. Allen: "Daylight and Town Planning"; at 3.30 p.m.—Mr. W. J. Jones: "Fluorescent Lighting".

Friday, May 17

BRITISH ASSOCIATION OF CHEMISTS (at the Central Library, St. Peters Square, Manchester 2), at 6 p.m.—Prof. P. M. S. Blackett, F.R.S.: "The Social Implication of Recent Discoveries regarding Atomic Energy".

SHEFFIELD METALLURGICAL ASSOCIATION (at 196 West Street, Sheffield 1), at 6.30 p.m.—Dr. H. Roxbee Cox: "British Aircraft Gas Turbines".

Saturday, May 18

SCIENTIFIC FILM ASSOCIATION, PURE SCIENCE COMMITTEE (joint meeting with the MATHEMATICAL ASSOCIATION, at the Polytechnic, Regent Street, London, W.1), at 2.45 p.m.—Display of Mathematical Films.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER OR ASSISTANT LECTURER IN PARASITOLOGY in the Department of Zoology—The Secretary and Registrar, The University, Bristol (May 17).

SENIOR LECTURER (must possess an Honours Degree in Botany or Zoology) in the BIOLOGY SECTION of the Department of Pharmacy and Biology—The Principal, Central Technical College, Suffolk Street, Birmingham 1 (May 18).

HEAD OF THE ENGINEERING DEPARTMENT of Blackpool Technical College and School of Art—The Director of Education, 3 Caunce Street, Blackpool (May 18).

LECTURER able to teach SCIENCE, including CHEMISTRY, and MATHEMATICS to Matriculation standard, in the Croydon Polytechnic—The Education Officer, Education Office, Katharine Street, Croydon (May 18).

SUPERINTENDING GEOLOGIST, SENIOR GEOLOGISTS (4), a PETROLEUM GEOLOGIST, a MINING ENGINEER, and a GEOPHYSICIST, for the Geological Survey of India—The Secretary, General Department, Office of the High Commissioner for India, India House, Aldwych, London, W.C.2 (May 18).

SCIENTIFIC ASSISTANT IN THE BIOCHEMICAL SECTION—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (May 20).

GRADUATE LECTURER IN ELECTRICAL ENGINEERING, a LECTURER IN CHEMISTRY, a LECTURER IN PHYSICS, and a LECTURER IN MATHEMATICS, in the Blackburn Municipal Technical College and School of Art—The Director of Education, Education Offices, Library Street, Blackburn (May 20).

HEAD OF THE MINING AND GEOLOGY DEPARTMENT—The Principal and Clerk to the Governing Body, Wigan and District Mining and Technical College, Wigan (May 23).

PRINCIPAL OF THE BIRMINGHAM CENTRAL TECHNICAL COLLEGE—The Chief Education Officer, Education Offices, Council House, Margaret Street, Birmingham 3 (May 25).

DIRECTOR, National Metallurgical Laboratory, Jamshedpur—The Secretary, Council of Scientific and Industrial Research, Delhi (May 30).

DIRECTOR, National Chemical Laboratory, Poona—The Secretary, Council of Scientific and Industrial Research, The Mall, Delhi (May 30).

FOTHERINGHAM CHAIR OF LOGIC AND METAPHYSICS—The Bursar and Secretary, McGill University, Montreal, Canada (May 30).

ASSISTANT LECTURER IN GEOGRAPHY, and a DEMONSTRATOR IN BACTERIOLOGY—The Registrar, The University, Leeds 2 (May 31).

HEAD OF THE MECHANICAL ENGINEERING DEPARTMENT of Rugby College of Technology and Arts—The Organiser of Further Education in Rugby, College of Technology and Arts, Eastlands, Rugby (May 31).

LECTURER IN PHYSICS AND MATHEMATICS—The Registrar, Merchant Venturers' Technical College, Unity Street, Bristol 1 (May 31).

LECTURER (Grade II) IN THE DEPARTMENT OF ZOOLOGY, a LECTURER (Grade III) IN THE DEPARTMENT OF GEOLOGY, and a LECTURER (Grade III) IN THE DEPARTMENT OF PHYSICS—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4 (May 31).

STATISTICIAN in the General Register Office—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 1468 (May 31).

LECTURER IN THE DEPARTMENT OF BACTERIOLOGY, a LECTURER IN PHYSICS, and a LECTURER (temporary) IN THE DEPARTMENT OF BACTERIOLOGY—The Registrar, King's College, Newcastle-upon-Tyne (June 1).

RESEARCH OFFICER, Division of Industrial Chemistry, Melbourne—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2 (June 11).

LECTURER IN INDUSTRIAL HEALTH—The Registrar, The University, Manchester 13 (June 21).

CHAIR OF MORBID ANATOMY tenable at London Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 25).

CHAIR OF BOTANY, the CHAIR OF PHYSICS, and the CHAIR OF AGRICULTURE—The Registrar, The University, Sydney, N.S.W., Australia (August 1).

ANALYTICAL CHEMIST in the Geological Survey Department of the Government of Southern Rhodesia—The Director, Southern Rhodesia Geological Survey, P.O. Box 366, Salisbury, Southern Rhodesia.

LECTURER IN INORGANIC CHEMISTRY—The Principal, Medway Technical College, Gardiner Street, Gillingham, Kent.

TECHNICAL ASSISTANTS (3, male) IN THE DEPARTMENT OF ECONOMICS (Agricultural Economics)—The Secretary and Registrar, The University, Bristol.